DOE/NV11718--605

NEVADA TEST SITE

ANNUAL SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 2000

October 2001

Prepared by Bechtel Nevada
Post Office Box 98521
Las Vegas, NV 89193-8521

Prepared for the
U.S. Department of Energy
National Nuclear Security Administration
Nevada Operations Office
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DISCLAIMER

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MEASUREMENT UNITS AND NOMENCLATURE

Radioactivity data in this report are expressed in both traditional units (e.g., pCi/L) and International System (abbreviated SI) units. These units are explained below.

background Ambient background radiation to which people are exposed. Naturally occurring radioactive elements contained in the body, in the ground, and in construction materials, cosmic radiation, and radioactivity in the air all contribute to an average radiation dose equivalent to humans of about 350 mrem per year. In laboratory measurements of radioactivity in samples, background is the activity determined when a sample of distilled water is processed through the system (Also called a blank).

becquerel Abbreviation Bq. The Bq is the SI unit for disintegration rate.
1 Bq = 1 disintegration per second.

concentration Activity per unit volume or weight. Usually expressed as µCi/mL, pCi/m^3 or pCi/g.

curie Abbreviation Ci. The historic unit for disintegration rate. 1 Ci = 3.7 x 10^{10} disintegrations per second = 3.7 x 10^{10} Bq. The usual submultiples of Ci are mCi (10^{-3} Ci or one thousandth Ci), µCi (10^{-6} Ci or one millionth Ci), and pCi (10^{-12} or one trillionth Ci).

EDE Effective dose equivalent - radiation dose corrected by various weighting factors that relate dose to the risk of serious effects.

rem Rem (for roentgen equivalent man) is the unit for expressing dose equivalent, or the energy imparted to a person when exposed to radiation. The commonly used subunit is the millirem (10^{-3} rem or one thousandth rem), abbreviated mrem.

roentgen Abbreviation R. A unit expressing the intensity of X or γ radiation at a point in air. The usual unit is mR or 10^{-3} R (one thousandth R).

volume The SI unit for volume is m^3 (cubic meter). Other units used are liter (L) and mL (10^{-3} L or one thousandth liter). One cubic meter = 1,000 L, 1 L = 1.06 quarts.

The elements and corresponding symbols used in this report are:

Element	Symbol	Element	Symbol
Actinium	Ac	Iron	Fe
Aluminum	Al	Krypton	Kr
Argon	Ar	Lead	Pb
Arsenic	As	Lithium	Li
Barium	Ba	Mercury	Hg
Beryllium	Be	Nitrogen	N
Bismuth	Bi	Oxygen	O
Boron	B	Plutonium	Pu
Cadmium	Cd	Potassium	K
Calcium	Ca	Radium	Ra
Cesium	Cs	Radon	Rn
Chlorine	Cl	Selenium	Se
Chromium	Cr	Silver	Ag
Cobalt	Co	Strontium	Sr
Copper	C	Thallium	Tl
Europium	Eu	Thorium	Th
Fluorine	F	Thulium	Tm
Hydrogen	H	Tritium	^{3}H
Iodine	I	Uranium	U

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LIST OF ACRONYMS AND ABBREVIATIONS

AA	Alluvial Aquifer
AIP	Agreement in Principle
AMEM	Assistant Manager for Environmental Management
ANOVA	Analysis of Variance
APCD	Air Pollution Control Division
ARL/SORD	Air Resources Laboratory, Special Operations and Research Division
ASA	Auditable Safety Analysis
ASCII	American Standard Code for Information Interchange
ASER	Annual Site Environmental Report
ASL	Analytical Services Laboratory
ASN	Air Surveillance Network
BCG	Biota Concentration Guide
BEEF	Big Explosives Experimental Facility
BEIDMS	Bechtel Environmental Integrated Data Management System
BHPS	Bureau of Health Protection Services
BLM	Bureau of Land Management
BN	Bechtel Nevada
BOD	Biochemical Oxygen Demand
CAA	Clean Air Act
CADD	Corrective Action Decision Document
CAIP	Corrective Action Investigation Plan
CAP	Corrective Action Plan
CAP88-PC	Clean Air Package 1988 (EPA software program for estimating doses)
CAS	Corrective Action Site
CAU	Corrective Action Unit
CEDE	Committed Effective Dose Equivalent
CEI	Compliance Evaluation Inspection
CEMP	Community Environmental Monitoring Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CGTO	Consolidated Group of Tribes and Organizations
CP	Control Point
CRMP	Community Radiation Monitoring Program
CTLP	Community Technical Liaison Program
CWA	Clean Water Act
CX	Categorical Exclusion
CY	Calendar Year
DAC	Derived Air Concentration
DAF	Device Assembly Facility
DAS	Disposal Authorization Statement
DCG	Derived Concentration Guide
D&D	Deactivation and Decommissioning
DDR	Data Discrepancy Report
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE/HQ	DOE Headquarters
DOELAP	DOE Laboratory Accreditation Program
DOE/NV	DOE Nevada Operations Office
DQO	Data Quality Objectives

DRI	Desert Research Institute, University and Community College System, Nevada
DWR	Division of Water Resources
EA	Environmental Assessment
EDE	Effective Dose Equivalent
EHS	Extremely Hazardous Substances
EIS	Environmental Impact Statement
ELU	Ecological Landform Unit
EMAC	Ecological Monitoring and Compliance
EML	Environmental Measurements Laboratory (DOE)
EO	Executive Order
EOD	Explosive Ordnance Disposal (NTS)
EODU	Explosive Ordnance Disposal Unit
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Reporting and Community Right-to-Know Act
ERA	Environmental Resource Associates
ERP	Environmental Restoration Project
ESA	Endangered Species Act
ESHD	Environment, Safety and Health Division
ET	Evapotranspiration
FFACO	Federal Facilities Agreement and Consent Order
FFCAct	Federal Facilities Compliance Act
FIFRA	Federal Insecticide Fungicide and Rodenticide Act
FY	Fiscal Year
GCD	Greater Confinement Disposal
GCU	Granite Confining Unit
GIS	Geographic Information System
gpm	Gallons per Minute
HGU	Hydrogeologic Unit
HRMP	Hydrologic Resources Management Program
HSC	Hazardous Materials Spill Center
HSU	Hydrostratigraphic Unit
HTO	Tritiated Water
HWSU	Hazardous Waste Storage Unit
ICMP	Integrated Closure and Monitoring Plan
ICRP	International Commission on Radiological Protection
ID	Identification
IICU	Intrusive Confining Unit
INEEL	Idaho National Engineering and Environmental Laboratory
IT	International Technology
JASPER	Joint Actinide Shock Physics Experimental Research Facility
LANL	Los Alamos National Laboratory
LAO	Los Alamos Operations (BN)
LCA	Lower Carbonate Aquifer
LCA3	Lower Carbonate Aquifer, Upper Thrust Plate
LCCU	Lower Clastic Confining Unit
LDR	Land Disposal Restrictions
LLNL	Lawrence Livermore National Laboratory
LLW	Low Level (Radioactive) Waste
LLWMU	Low Level Waste Management Unit
LO	Livermore Operations (BN)
LTHMP	Long-Term Hydrological Monitoring Program
MAPEP	Mixed Analyte Performance Evaluation Program
MDC	Minimum Detectable Concentration

MEI	Maximally Exposed Individual
MGCU	Mesozoic Granite Confining Unit
MLLW	Mixed Low Level Waste
MOU	Memorandum of Understanding
MQO	Measurement Quality Objectives
MSL	Mean Sea Level
MTRU	Mixed Transuranic
NAC	Nevada Administrative Code
NAFR	Nellis Air Force Range
NAGPRA	Native American Graves Protection and Repatriation Act
NDEP	Nevada Division of Environmental Protection
NDOW	Nevada Division of Wildlife
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NIST	National Institute of Standards and Technology
NLVF	North Las Vegas Facility (BN)
NNSA/NV	National Nuclear Security Administration, Nevada Operations Office
NPDES	National Pollution Discharge Elimination System
NR	National Register
NRHP	National Register of Historic Places
NRS	Nevada Revised Statues
NSHPO	Nevada State Historic Preservation Office
NTS	Nevada Test Site
NTSWAC	Nevada Test Site Waste Acceptance Criteria
NVLAP	National Voluntary Laboratory Accreditation Program (NIST)
OEMP	Offsite Environmental Monitoring Program
ORSP	Offsite Radiological Safety Program
P2	Pollution Prevention
PA	Performance Assessment
PCB	Polychlorinated Biphenyl
PE	Performance Evaluation
PEP	Performance Evaluation Program
PES	Performance Evaluation Study
PIC	Pressurized Ion Chamber
PM-OV	Pahute Mesa-Oasis Valley
PPOA	Pollution Prevention Opportunity Assessments
QA	Quality Assurance
QAP	Quality Assessment Program
RBRC	Rechargeable Battery Recycling Corporation
RCRA	Resource Conservation and Recovery Act
RCT	Radiological Control Technician
R&IE-LV	Radiation & Indoor Environments National Laboratory - Las Vegas (EPA)
RMAD	Reactor Maintenance Assembly and Disassembly
RMP	Resource Management Plan
ROD	Record of Decision
RREMP	Routine Radiological Environmental Monitoring Plan
RSD	Relative Standard Deviation
RSL	Remote Sensing Laboratory (BN)
RT	Rainier Test
RWID	Radioactive Waste Information Document
RWMBART	Radioactive Waste Management Basis Assistance and Review Team
RWMS	Radioactive Waste Management Site

RWMS-3	Radioactive Waste Management Site, Area 3
RWMS-5	Radioactive Waste Management Site, Area 5
SAFER	Streamlined Approach for Environmental Restoration
SARA	Superfund Amendments and Reauthorization Act
SCCC	Silent Canyon Caldera Complex
SDWA	Safe Drinking Water Act
SERDP	Strategic Environmental Research and Development Program
SQL	Structured Query Language
STL	Special Technologies Laboratory (BN)
SWL	Static Water Level
SWNVF	Southwest Nevada Volcanic Field
SWRWMP	Sitewide Radioactive Waste Management Program
TaDD	Tactical Demilitarization Development
TCU	Tuff Confining Unit
TLD	Thermoluminescent Dosimeter
TMA	Timber Mountain Aquifer
TMCC	Timber Mountain Caldera Complex
TRU	Transuranic
TSA	Topopah Spring Asquifer
TSCA	Toxic Substances Control Act
TTR	Tonopah Test Range
UCCU	Upper Clastic Confining Unit
UGTA	Underground Testing Area
U.S.	United States of America
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	Underground Storage Tank
VCU	Volcaniclastic Confining Unit
VZM	Vades Zone Monitoring
WAMO	Washington Aerial Measurements Operations (BN)
WEF	Waste Examination Facility
WI	Work Instructions
WIPP	Waste Isolation Pilot Plant
WPM-OV	Western Pahute Mesa - Oasis Valley
WRCC	Western Regional Climate Center
WVCU	Wahmonie Volcanic Confining Unit
YF-LCU	Yucca Flat Lower Confining Unit
YMP	Yucca Mountain Program

1.0 SUMMARY

Monitoring and surveillance, on and around the Nevada Test Site, (NTS) by United States Department of Energy (DOE) National Nuclear Security Administration Nevada Operations Office (NNSA/NV) contractors and NTS user organizations during 2000, indicated that operations on the NTS were conducted in compliance with applicable NNSA/NV, state, and federal regulations and guidelines. All discharges of radioactive liquids remained onsite in containment ponds, and there was no indication of migration of radioactivity to the offsite area through groundwater. During 2000, no accidental or unplanned releases occurred on the NTS. Oversite surveillance by the Desert Research Institute (DRI) of the University and Community College System of Nevada around the NTS indicated that airborne radioactivity from diffusion and evaporation of liquid effluents was not detectable offsite. However, low levels of airborne $^{239+240}Pu$ (< 2 percent of the Derived Concentration Guide [DCG]) were detected offsite by high-volume air samplers. Using the U.S. Environmental Protection Agency's (EPA's) Clean Air Package 1988 model (CAP88-PC) and NTS radionuclide emissions by the resuspension of soil and environmental monitoring data, the effective dose equivalent (EDE) to the maximally exposed individual (MEI) offsite was calculated to be 0.17 mrem. This value is 1.7 percent of the federal dose limit prescribed for radionuclide air emissions. The EDEs calculated from measured radioactivity concentrations by high-volume offsite air samplers were all less than the model prediction. Levels detected are consistant with the surrounding area fallout soil concentration from past atmospheric testing. The MEI receiving this dose would also have received an external exposure of 143 mrem from natural background radiation. A maximized estimate of the EDE to the MEI, from the inhalation of NTS airborne emissions and the ingestion of wild life, was calculated to be 0.33 mrem/yr (0.0033 mSv/yr), which is only 0.33 percent of the 100 mrem/yr dose limit to the general public. There were no nonradiological releases to the offsite area. Hazardous wastes were shipped offsite to approved disposal facilities. Compliance with the various regulations stemming from the National Environmental Policy Act (NEPA) is being achieved and, where mandated, permits for air and water effluents and waste management have been obtained from the appropriate agencies. Cooperation with other agencies has resulted in 12 different agreements, memoranda, and consent orders.

Biota Concentration Guides derived by the DOE Biota Dose Assessment Committee were used to determine that the radiation doses to terrestrial biota in all areas of the NTS are in compliance with a proposed DOE regulatory standard for biota.

Support facilities at off-NTS locations have complied with the requirements of air quality permits and state or local wastewater discharge and hazardous waste permits as mandated for each location.

1.1 ENVIRONMENTAL MANAGEMENT

The NNSA/NV is committed to increasing the quality of its management of NTS environmental resources. This has been promoted by the establishment of an Environment, Safety and Health Division under the purview of the Assistant Manager for Technical Services and by upgrading the Environmental Management activities to the Assistant Manager level to address those environmental issues that have arisen in the course of performing the original primary mission of the NNSA/NV, i.e., underground testing of nuclear explosive devices. NNSA/NV management has vigorously promoted the practice of pollution prevention, including waste minimization and material recycling.

Operational releases and seepage of radioactivity are reported soon after their occurrence. In compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP), as set forth in Title 40 Code of Federal Regulations Part 61, the accumulated annual emissions are used as part of the input to the EPA's CAP88-PC software program (DOE 1997b) to calculate potential EDEs to people living beyond the boundaries of the NTS and the surrounding exclusion areas.

RADIOLOGICAL ENVIRONMENT

Radiological effluents in the form of air emissions and liquid discharges are not normally released into the environment as a routine part of operations on the NTS. Radioactivity in liquid discharges released to onsite waste treatment or disposal systems (containment ponds) is monitored to assess the efficacy of treatment and control and to provide an annual summary of released radioactivity. Air emissions are monitored for source characterization and operational safety as well as for environmental surveillance purposes.

Air emissions in 2000 consisted primarily of small amounts of tritium and plutonium that were assumed to be released to the atmosphere and were attributed to:

- Diffusion of tritiated water (HTO) vapor from evaporation of HTO from tunnel and characterization well containment ponds.

- Diffuse emissions calculated from the results of environmental surveillance activities.

- Resuspension of plutonium calculated by use of resuspension equations.

Diffuse emissions in 2000 included HTO, only slightly above detection limits, from the Radioactive Waste Management Site in Area 5 (RWMS-5), E Tunnel Pond #2, the SEDAN crater in Area 10, and the SCHOONER crater in Area 20 and resuspended $^{239+240}$Pu from areas on the NTS, where it was deposited by atmospheric nuclear tests or device safety tests in earlier years. Table 1.1 shows the quantities of radionuclides assumed to be released from all sources, including postulated loss of standards during laboratory operations. The radioactive materials listed in this table were not detected in the offsite area above ambient radioactivity levels. Onsite liquid discharges to containment ponds included approximately 14 Ci (0.52 TBq) of tritium. This was a reduction of 40 percent from the tritium discharge last year. Tritium emissions were detected by air sampling at SEDAN and SCHOONER sites and the tunnel containment ponds. No liquid effluents were discharged to offsite areas.

ONSITE ENVIRONMENTAL SURVEILLANCE

Environmental surveillance on the NTS is designed to cover the entire area with some emphasis on areas of past nuclear testing and present operational activities. In 2000, samplers were operated at 33 locations on and near the NTS to collect air particulate samples and at 12 locations to collect HTO in atmospheric moisture. Grab samples were collected frequently from water supply wells, water taps, containment ponds, and sewage lagoons. Thermoluminescent dosimeters (TLDs) were placed at 86 locations on the NTS to measure ambient gamma exposures.

Data from these networks are summarized as annual averages for each monitored location. Those locations with concentrations above the NTS average are assumed to reflect onsite emissions. These emissions arise from diffuse (areal) sources and from certain operational activities (e.g., radioactivity buried in the low-level radioactive waste [LLW] site).

Approximately 520 air samples were analyzed by gamma spectroscopy. All isotopes detected by gamma spectroscopy were naturally occurring in the environment (^{40}K, ^{7}Be, and members of the uranium and thorium series), except for 37 samples in which very low levels of ^{137}Cs were detected.

Gross beta analysis of the air samples yielded an annual mean for the network of 2.1 x 10^{-14} µCi/mL (0.78 mBq/m^3). Plutonium analyses of monthly NTS composited air filters indicated an annual network mean of 46 x 10^{-18} µCi/mL (1.7 µBq/m^3) for $^{239+240}$Pu and 2.6 x 10^{-18} µCi/mL (0.096 µBq/m^3) of ^{238}Pu for all locations during 2000.

Slightly higher concentrations were found in samples from certain areas, but they were calculated to be only 2.3 percent of the Derived Air Concentration for exposure to workers. Higher than background levels of plutonium are to be expected in some air samples because fallout from atmospheric tests in the 1950s, and nuclear safety tests in the 1950s and 1960s dispersed plutonium over a small portion of the NTS's surface.

Atmospheric moisture was collected for two-week periods at 12 locations on the NTS and analyzed for HTO content. The annual network mean of (42 ± 152) x 10^{-6} pCi/mL (1.6 ± 5.6 Bq/m^3) was slightly higher than last year. The highest annual mean concentrations were at the SCHOONER crater, SEDAN crater, and the E Tunnel pond in that order. The primary radioactive liquid discharge to the onsite environment in 2000 was about 14 Ci (0.52 TBq) of tritium (as HTO) in seepage from E Tunnel and from water pumped from wells into containment ponds. When calculating the dose for the offsite public, it was assumed that all of the HTO had evaporated.

Surface water sampling was conducted at two containment pond and the effluent for the Area 12 E Tunnel. A grab sample was taken from each of these surface water sites for analysis of gross beta, tritium, gamma-emitters, and plutonium isotopes. Strontium-90 was analyzed once per year for each location. Samples collected from the tunnel containment pond and Well RNM-25 contained detectable levels of radioactivity, as would be expected. Water samples were collected from the sewage lagoons and contained background levels of gross beta, tritium, plutonium, and strontium.

Water samples from onsite supply wells and drinking water distribution systems were also analyzed for radionuclides. The supply well average gross beta activity of 6.9 x 10^{-9} µCi/mL (0.25 Bq/L) was 2 percent of the DCG for ^{40}K (used for comparison purposes); gross alpha was 6.3 x 10^{-9} µCi/mL (0.21 Bq/L), which was 42 percent of the drinking water standard; the concentrations of ^{3}H, ^{90}Sr, $^{239+240}Pu$, and ^{238}Pu were all below their respective minimum detectable levels of about 16.7 x 10^{-9} µCi/mL (0.62 Bq/L), 0.35 x 10^{-9} µCi/mL (13 mBq/L), and 0.016 x 10^{-9} µCi/mL (0.59 mBq/L). During the fourth quarter, four wells were at or slighty above the analytical detection limits, ranging from 14.1 to 32.7 x 10^{-9} µCi/mL (0.52 to 1.2 Bq/L), resampled results were below detection limits.

Monitoring of the vadose zone beneath the waste management sites in Areas 3 and 5 revealed that wetting fronts extended only a few feet below the floor of these sites. Also, Resource Conservation and Recovery Act (RCRA) monitoring wells, for sampling groundwater under RWMS-5, indicated that contamination from mixed waste buried therein is not detectable in the well samples.

Analysis of the TLD network showed that the 10 historic stations had an average annual exposure of 104 mR, while the 14 boundary stations (located at higher elevation) had a higher average annual exposure of 132 mR. Both exposures were consistent with previous data.

Monitoring System Design

During 1998, in an effort to make the environmental surveillance system on the NTS more efficient, it was redesigned. Using the Seven-Step Data Quality Objective (DQO) process, published by EPA, and information on the distribution and amount of radioactive sources on the NTS, a “Routine Radiological Environmental Monitoring Plan” (RREMP) was developed (DOE 1998a). As a result of the DQO process, some monitoring was eliminated in 1999. The number of air and TLD monitoring stations were reduced, and monitoring frequencies were also changed in 1999. The monitoring was conducted in accordance with the Plan during 2000. The Plan was implemented in the latter part of 1998 and is scheduled for review at the end of 2001.

OFFSITE ENVIRONMENTAL SURVEILLANCE

The offsite radiological compliance monitoring was conducted around the NTS at six locations using high-volume air samplers. The high-volume samplers collects ten times the volume of air, providing lower detection limits and greater sensitivity to confirm the concentrations predicted by modeling efforts. Plutonium analyses of monthly offsite composite air filters indicated an annual network mean of 8 x 10^{-18} µCi/mL (0.29 µBq/m^3) $^{239+240}Pu$ and 0.72 x 10^{-18} µCi/mL (0.027 µBq/m^3) for ^{238}Pu during 2000. The calculated mean EDE at the measurement locations by CAP88-PC model is 0.056 mrem and by measured mean EDE is 0.025 mrem.

Oversite radiological monitoring is conducted by public individuals in communities and at ranches around the NTS, and is coordinated by the DRI of the University and Community College System of Nevada under contract with NNSA/NV. The EPA Radiation and Indoor Environments National Laboratory administered an additional ranch station network in 2000. These programs consist of several environmental sampling, radiation detection, and dosimetry networks as described below. A network of 20 Community Environmental Monitoring Program (CEMP) stations were operated continuously during 2000. During 2000, no airborne radioactivity related to current activities at the NTS was detected on any sample from low-volume samplers.

In 2000, external exposure was monitored by a network of 20 TLDs and pressurized ion chambers (PICs) located in towns and communities around the NTS. The PIC network in the communities surrounding the NTS indicated background exposures, ranging from 68 to 152 mR/yr, that were consistent with previous data and well within the range of background data in other areas of the United States. The exposures measured by the TLDs were slightly less, as has been true in the past.

Although no radioactivity attributable to current NTS operations was detected by any of the offsite monitoring networks, based on the NTS airborne releases, an atmospheric dispersion model calculation (CAP88-PC) indicated that the maximum potential EDE to any offsite individual would have been 0.17 mrem (1.7×10^{-3} mSv) at Springdale, and the dose to the population within 80 km of the several emission sites on the NTS would have been 0.44 person-rem (4.4×10^{-3} person-Sv), both of which were similar to last year. If one assumes that the MEI at Springdale also ate the meat of wild life which had migrated off the NTS after eating and drinking in radioactively contaminated areas, he could have received an additional EDE of 0.16 mrem/yr (0.0016 mSv/yr). These added to the air pathway EDE gives a total of 0.33 mrem/yr (0.0033 mSv/yr). For comparison, the hypothetical person receiving this dose would also have been exposed to 152 mrem/yr (1.52 mSv/yr) from natural background radiation. A summary of the potential EDEs due to operations at the NTS is presented in Table 1.2.

In compliance with the regulatory standards published by the DOE Biota Dose Assessment Committee, the dose to terrestrial biota was calculated for the most contaminated NTS areas. All such areas were in compliance with the committee's technical standard.

LOW-LEVEL WASTE DISPOSAL

Environmental monitoring at the RWMS, Area 3 (RWMS-3) has detected plutonium in air samples. However, the upwind/ downwind sampler results were equivalent, and plutonium was detected in other air samples from Area 3, indicating that the source is resuspended plutonium from areas surrounding RWMS-3. Elevated levels of plutonium have been detected in air samples from several areas on the NTS where operational activities, vehicular traffic, and high winds resuspend plutonium for detection by air sampling. The presence of plutonium on the NTS is primarily due to atmospheric and safety tests conducted in the 1950s and 1960s. These tests spread plutonium on surface soil in the eastern and northwestern areas of the NTS (Figure 2.3, Chapter 2.0 displays these locations).

Environmental monitoring at and around RWMS-5 indicated that HTO in air was detectable at, but not beyond, the waste site boundaries. This monitoring included air sampling, water sampling, and external gamma exposure measurement. Vadose zone monitoring for water seepage is conducted beneath RWMS-3 and RWMS-5, as a method of detecting any downward migration of waste. Also, three monitoring wells, installed to satisfy RCRA requirements for a mixed-waste disposal operation at RWMS-5, have not yet detected any migration of hazardous materials.

NONRADIOLOGICAL MONITORING

Nonradiological environmental monitoring of NTS operations involved only onsite monitoring because there were no discharges of nonradiological hazardous materials to offsite areas. The primary environmental permit areas for the NTS were monitored to verify compliance with ambient air quality and the RCRA requirements. Air emissions sources common to the NTS included particulates from construction, aggregate production, surface disturbances, fugitive dust from unpaved roads, fuel burning equipment, open burning, and fuel storage facilities. NTS environmental permits active during 2000, which were issued by the state of Nevada or by federal agencies, included one comprehensive air quality permit covering emissions from construction of facilities, boilers, storage tanks, and surface disturbances; three onsite open-burn variances; one offsite permit for surface disturbance (environmental restoration activities); seven permits for onsite drinking water distribution systems; one permit for sewage discharges to lagoon collection systems; five permits for seepage hauling; one incidental take permit for the threatened desert tortoise; and one permit for the scientific collection and study of various species on the NTS. Further, a RCRA permit has been obtained for general NTS operations and for two specific facilities on the NTS.

Permits at non-NTS operations included 12 air pollution control permits, 1 sewage discharge permit, and 2 hazardous material storage permits.

The only nonradiological air emission of regulatory concern under the Clean Air Act (CAA) has been due to asbestos removal during building renovation projects and from insulated piping at various locations on the NTS. During 2000, there were no projects that required state of Nevada notifications. The annual estimate for non-scheduled asbestos demolition/renovation projects for fiscal year 2000 was sent to EPA Region 9 in December 13, 1999.

RCRA requirements were met through an operating permit for hazardous waste storage and explosives ordnance disposal. NTS operations also include mixed waste storage through a Consent Agreement between NNSA and the state of Nevada.

As there are no liquid discharges to navigable waters, offsite surface water drainage systems, or publicly owned treatment works, no Clean Water Act (CWA) National Pollution Discharge Elimination System (NPDES) permits were required for NTS operations. Under the conditions of the state of Nevada operating permits, liquid discharges to onsite sewage lagoons are regularly tested for biochemical oxygen demand, pH, and total suspended solids. In addition to the state-required monitoring, these influents were also tested for RCRA related constituents as an internal initiative to further protect the NTS environment.

There were no formal state inspections of NTS equipment regulated by the state air quality permit. In May of 2000, NNSA/NV inspected area 25 for industrial discharges.

In compliance with the Safe Drinking Water Act (SDWA) and four drinking water supply system permits from the state, the onsite distribution systems supplied by onsite wells are sampled either monthly or quarterly for coliform bacteria and water quality parameters, depending on the status as a community or non-community system.

1.2 COMPLIANCE ACTIVITIES

NNSA/NV is required to comply with various environmental laws and regulations in the conduct of its operations. Monitoring activities required for compliance with the CAA, CWA, SDWA, Toxic Substance Control Act, and RCRA are summarized above. Endangered Species Act activities include compliance with the United States Fish and Wildlife Service (USFWS) Biological Opinion on NTS Activities and the Biological Opinion on Fortymile Canyon Activities. NEPA activities include one Environmental Assessment, and 17 Categorical Exclusions. Of the 60 NEPA checklist completed, 42 projects were excluded because they had been considered in the site-wide Environmental Impact Statement or the Record of Decision.

Wastewater discharges at the NTS are not regulated under NPDES permits, because all such discharges are to onsite sewage lagoons. Discharges to these lagoons are permitted under the Nevada Water Pollution Control Act. Wastewater discharges from the non-NTS support facilities were within the regulated levels established by city or county publicly owned treatment works.

The National Historic Preservation Act directs federal agencies to consult with Native Americans when NNSA/NV programs or activities at the NTS may impact their environmental and cultural interests. In 2000, work continued on a summary report, site records, and an artifact inventory of materials in the NNSA/NV Curatorial Facility. The final Fourtymile Canyon rock art sites report was issued. Consultations with several Native American tribes were conducted to determine whether artifact collections should be repatriated.

The Ecological Monitoring and Compliance Program monitoring tasks, which were selected for 2000 included habitat mapping of the NTS, characterizing the natural wetlands on the NTS, conducting a census of the horse population, surveying bat species, surveying for raptors, and periodically monitoring man-made water sources to assess their effects on wildlife. Reviews of spill test plans for the Hazardous Materials Spill Center were also conducted.

Field surveys were conducted from June 1996 through February 1998 to identify those natural NTS springs, seeps, tanks, and playas, which could be designated by the United States Army Corps of Engineers as jurisdictional wetlands. During 2000, five of these wetlands were visited to characterize seasonal trends in physical and biological parameters.

The annual compliance report for calendar year 2000 NTS activities was prepared and submitted to the USFWS.

Pollution prevention activities conducted at the NTS and its offsite facilities involve active programs for recycling, material exchange, and waste minimization.

1.3 GROUNDWATER PROTECTION

No radioactivity was detected above background levels in the groundwater sampling network surrounding the NTS. Low levels of tritium, in the form of HTO, were detected in onsite wells used only for monitoring purposes and not for drinking water.

Because wells that were drilled for water supply or exploratory purposes are used in the NTS monitoring program, rather than wells drilled specifically for groundwater monitoring, a program of well drilling for groundwater characterization at the NTS is underway. The design of the program is for installation or recompletion of groundwater characterization wells at strategic locations on and near the NTS. Through 2000, three wells were completed, one offsite west of the NTS and two in Frenchman Flats area. Hydrological tests and sampling were completed at eight wells drilled before 2000.

Related activities included studies of groundwater transport of contaminants (radionuclide migration studies) and nonradiological monitoring for water quality assessment and RCRA requirements.

1.4 RADIOACTIVE AND MIXED WASTE STORAGE AND DISPOSAL

Two RWMSs are operated on the NTS: one each in Areas 3 and 5. During 2000, the RWMSs received LLW generated at the NTS and other NNSA/NV facilities. Waste is disposed of in shallow pits and trenches in RWMS-5 and in subsidence craters in RWMS-3.

At RWMS-5, LLW is disposed of in standard packages. Transuranic (TRU) and TRU mixed wastes are stored on a curbed asphalt pad on pallets in overpacked 55-gal drums and steel boxes. These will be characterized prior to shipment to the Waste Isolation Pilot Plant in New Mexico. The RWMS-3 is used for disposal of bulk LLW waste and LLW that is packaged, including packages that are larger than the specified standard size used at RWMS-5.

Environmental monitoring at both sites included air sampling for radioactive particulates and measurement of external exposure using TLDs. Water sampling and vadose zone monitoring for moisture and hazardous constituents are conducted at the RWMS-5, as is monitoring for tritium in atmospheric moisture. Environmental monitoring results for 2000 indicated that measurable radioactivity from waste disposal operations was detectable only in the immediate vicinity of the facilities.

Because the NTS is not a RCRA-permitted disposal facility, RCRA regulations require the shipment of nonradioactive hazardous waste to licensed disposal facilities offsite. Therefore hazardous waste is not disposed of onsite.

LLW is accepted for disposal only from generators (onsite and offsite) that have submitted a waste application that meets the requirements of the Waste Acceptance Criteria document (DOE 1996e) and that have received NNSA/NV approval of the waste stream(s) for disposal at the NTS.

1.5 QUALITY ASSURANCE

The NTS's quality assurance (QA) program ensures the collection and analysis of samples for radiological parameters to meet customer-and regulatory-defined requirements. Data quality is assured through process-based QA, procedure-specific QA, measurement quality objectives, and performance evaluation programs. The QA program for radiological data consists of participation in the Quality Assessment Program administered by the NNSA/NV Environmental Measurements Laboratory, the InterLaB RadCheM™ Proficiency Testing Program directed by Environmental Resource Associates, the Radiochemistry Intercomparison Program provided by the National Institute of Standards and Technology, and the Mixed Analyte Performance Evaluation Program conducted by the Idaho National Engineering and Environmental Laboratory. TLD radiation measurement QA for the program is assessed by the Bechtel Nevada Dosimetry Group's participation in the NNSA/NV's Laboratory Accreditation Program and intercomparisons provided by the Battelle Pacific Northwest National Laboratory during the course of the year.

1.6 ISSUES AND ACCOMPLISHMENTS

PRINCIPAL COMPLIANCE PROBLEMS FOR 2000

- Results for lead were found above the SDWA action level in the Area 12, Building 12-43 drinking water systems. The water is restructured to non-potable use until a remedy is found for this situation.

ACCOMPLISHMENTS FOR 2000

- The RREMP uses a DQO approach to identify the environmental data that must be collected for regulatory compliance and provides QA, Analysis and Sampling Plans to ensure that defensible data are generated. The RREMP provides one common integrated approach for all routine environmental monitoring both on and off the NTS. Other facilities also included in the RREMP are the associated NNSA facilities at the North Las Vegas Facility, the Remote Sensing Laboratory (RSL) - Nellis, the Los Alamos Operations, the Special Technologies Laboratory, and the RSL-Andrews.

- The Bechtel Environmental Integrated Data Management System (BEIDMS), Oracle relational database, replaced the Laboratory Data Analysis System for the storage, documentation and retrieval for all environmental sampling results. BEIDMS integrates the preparation of chain-of-custody, sample labeling, QA, data verification/validation, and user-friendly querying in one system providing greater assurance that the data are defensible.

- Sample package documents were developed for all environmental sampling media providing guidance to the sampler to ensure consistency and quality, collection of all field notes and comments, and safety guidance and work control. Document are scanned and electronic archived. Selected is entered in BEIDMS.

- NEPA Environmental Evaluation Checklists were completed for 60 proposed projects.

- Throughout 2000, NNSA/NV continued to maintain and update the "NNSA/NV Compliance Guide" (Volume III), a handbook containing procedures, formats, and guidelines for personnel responsible for NEPA compliance activities.

In 2000, the following accomplishments were achieved in the management of cultural resources at the NTS:

- Five cultural resources, one inventory, and five historical evaluations were conducted on NTS facilities to determine eligibility for National Register of Historic Places (NRHP). Cane Springs was determined to be eligible for listing on the NRHP.

- Operations conducted under the Nevada Operations Site Pollution Prevention Program in 2000 resulted in recycle or new uses of nearly 2.56 metric tons of materials. Several employee awareness projects were conducted: Integrated Safety Management Day, Family Days, and others.

- Continued use of a Just-in-Time supply system allowed NTS contractors to reduce product stock and control potentially hazardous products.

- Progress continued on the NTS groundwater characterization program by use of pumping programs on several wells to estimate yields and radionuclide content.

- Habitat maps of vegetation alliances on the NTS were completed to identify groups of visually similar vegetation, soils, slope, and hydrology which may warrant active protection from NNSA projects.

- Monitoring of 26 sensitive species of vegetation and animals was continued to ensure their continued presence on the NTS by protecting them from impacts of NNSA projects and to determine if further protection under state and federal laws is necessary.

- The state issued a RCRA Research, Development, and Demonstration Permit for the construction and operation of a facility to develop treatment methods for demilitarizing rocket motors.

1.7 CONCLUSION

The environmental monitoring results presented in this report document that operational activities on the NTS in 2000 were conducted so that no measurable radiological exposure occurred to the public in offsite areas. Calculation of the highest individual dose that could have been received by an offsite resident (based on estimation of onsite worst-case radioactive releases obtained by measurement or engineering calculation and assuming the person remained outdoors all year) equated to 0.17 mrem to a person living in Springdale, Nevada. If this same individual also was a hunter who ate a bag limit of doves which migrated from the NTS after drinking water from the E Tunnel ponds, he would also receive 0.16 mrem for a total of 0.33 mrem. This may be compared to that individual's exposure to 152 mrem/yr from natural background radiation as measured by the PIC instrument at Beatty, Nevada.

There were no major incidents of nonradiological contaminant releases to the environment in 2000. Many contaminated sites are on schedule for remediation, and intensive efforts to characterize and protect the NTS environment, implemented in 1990, were continued in 2000. The Underground Testing Area program and other activities devoted to characterization and protection of groundwater on and around the NTS continued on schedule.

Table 1.1 Radionuclide Emissions on the NTS - 2000[a]

Radionuclide	Half-life (years)	Quantity Released (Ci)[b]
Airborne Releases:		
^{3}H	12.35	431[c]
$^{239+240}Pu$	24065.[e]	3.2×10^{-1}[d]
^{241}Am	432.2	4.9×10^{-2}[d]

(a) Assumes worst-case point and diffuse source releases; there were no unplanned releases.

(b) Multiply by 37 to obtain GBq.

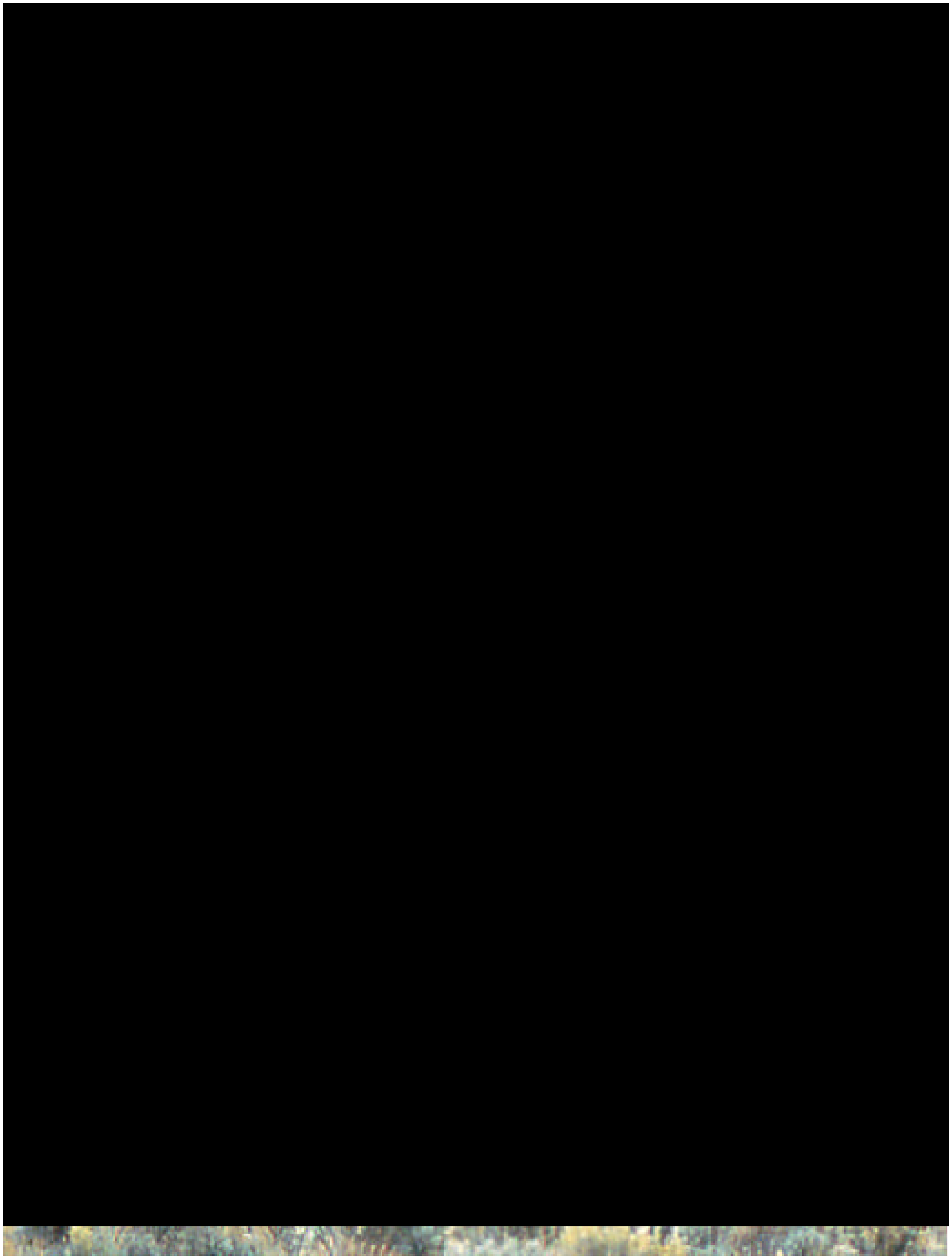
(c) Includes calculated data from air sampling results, postulated loss of laboratory standards, and evaporation of water from containment ponds.

(d) Calculated from the resuspension of surface deposits.

(e) This is the half-life of ^{239}Pu.

Table 1.2 NTS Radiological Dose Reporting - 2000

	Dose to Maximally Exposed Individual		Percent of DOE 100-mrem Limit	Estimated Population Dose			
Pathway	(mrem)	(mSv)		(person-rem)	(person-Sv)	Population within 80 km	Estimated Natural Radiation Dose (person-rem)
Air	0.17	0.0017	0.17	0.44	0.0044	38,381	5,830
Air and Wild Life	0.33	0.0033	0.33	0.44	0.0044	38,381	5,830



View of Shoshone Mountain (No Date Provided)

2.0 INTRODUCTION

The Nevada Test Site (NTS) environment is characterized by desert valley and Great Basin mountain terrain and topography, with a climate, flora, and fauna typical of the southern Great Basin deserts. The key features that afford protection to the inhabitants of the adjacent areas from potential exposure to radioactivity or other contaminants resulting from operations on the NTS are restricted access, extended wind transport times, bounded on three sides by United States Air Force lands, and the general remote location of the NTS. Also, characteristic of this area are the great depths to slow-moving groundwater and little or no surface water. Population density within 80 km of the NTS is only 0.5 persons/km^2 versus approximately 29 persons/km^2 in the 48 contiguous states. The predominant use of land surrounding the NTS is open range for livestock grazing with scattered mining and recreational areas.

The NTS, located in southern Nevada was the primary location for the testing of nuclear explosives in the continental United States from 1951 to 1992. Historically, nuclear testing has included, (1) atmospheric testing in the 1950s and early 1960s; (2) underground testing in drilled, vertical holes and horizontal tunnels; (3) earth-cratering experiments; (4) open-air nuclear reactor and engine testing; and (5) eleven underground tests for various purposes at other locations in the United States.

NTS activities in 2000 continue to be diverse, with the primary role being to help ensure that the existing United States stockpile remains safe and reliable. Facilities that support this mission include the U1 Facility, Big Explosives Experimental Facility (BEEF), and Joint Actinide Shock Physics Experimental Research Facility (JASPER). Other NTS activities include demilitarization activities, controlled spills of hazardous material at the Hazardous Materials Spill Center (HSC), remediation of industrial sites, processing of waste destined for the Waste Isolation Pilot Plant (WIPP), disposal of radioactive waste, and environmental research. In addition efforts continue to bring other business to the NTS, like aerospace and alternative energy technologies.

2.1 NTS SITE CHARACTERISTICS

The NTS, located in Nye County, Nevada, as shown in Figure 2.1, has been operated by the U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Operations Office (NNSA/NV), or its predecessors, as the on-continent test site for nuclear explosives testing since 1951. The southeast corner of the NTS is about 88 km (55 mi) northwest of the center of Las Vegas. By highway, it is about 105 km (65 mi) from the center of Las Vegas to Mercury. The NTS encompasses about 3,561 km^2 (1,375 mi^2), an area larger than the state of Rhode Island. The dimensions of the NTS vary from 46 to 56 km (28 to 35 mi) in width (eastern to western border) and from 64 to 88 km (40 to 55 mi) in length (northern to southern border). The NTS is surrounded on the east, north, and west sides by public exclusion areas, called the Nellis Air Force Range (NAFR) (see Figure 2.1). This area provides a buffer zone varying from 24 to 104 km (15 to 65 mi) between the NTS and public lands. The combination of the NAFR

and the NTS is one of the larger unpopulated land areas in the United States, comprising some 14,200 km^2 (5,470 mi^2). Figure 2.2 shows the general layout of the NTS, including the location of major facilities and the NTS Area numbers referred to in this report. The geographical areas previously used for nuclear testing are also indicated in Figure 2.2. Mercury, located at the southern end of the NTS, is the main base camp for worker housing and administrative operations for the NTS.

2.2 TOPOGRAPHY AND TERRAIN

The NTS terrain is typical of much of the Basin and Range physiographic province in Nevada, Arizona, and Utah. There are north to northeast trending mountain ranges separated by gentle sloping linear valleys and broad flat basins at the NTS. The principal valleys within the NTS are the Frenchman Flat, the Yucca Flat, and the Jackass Flats, with the principal highlands consisting of Pahute Mesa, Rainier Mesa, Timber Mountain, and Shoshone Mountain. A large portion of the NTS ranges in elevation from about 914 to 1,219 m (3,000 to 4,000 ft) in the valleys to the south and east to 1,676 to 2,225 m (5,500 to 7,300 ft) in the high country toward the northern and western boundaries.

Surface drainages for Yucca and Frenchman Flats (east side of the NTS) are closed-basin systems that drain onto the dry lake beds (playas) in each valley. The remaining area on the western side of the NTS drains via arroyos and dry stream beds that carry water only during unusually intense or persistent storms. There are no continuously flowing streams on the NTS.

One notable feature of Yucca Flat is the formation of numerous dish-shaped surface subsidence craters as a direct result of nuclear testing (other areas on the NTS are affected on a much smaller scale). Most underground nuclear tests conducted in vertical shafts (also cratering experiments or following some tunnel events) produced surface subsidence craters that occurred when the overburden above a nuclear cavity collapsed and formed a rubble "chimney" to the surface.

2.3 PRECIPITATION

The NTS is between the northern boundary of the Mojave Desert and the southern limits of the Great Basin Desert. This “Transitional Desert” is considered to be typical of either the Dry Mid-latitude or Dry Subtropical climatic zones. The climate is characterized by low precipitation, a large diurnal temperature range, a large evaporation rate, and moderate to strong winds.

Most precipitation in the Transitional Desert occurs in winter and summer. Winter precipitation is generally associated with transitory low-pressure systems originating from the west and occurring as uniform storms over large areas (snowfall to elevations below 5,000 feet in the strongest of these storms). Summer precipitation is generally associated with convective storms originating from the south or southwest and occurring as intense local storms. The average annual precipitation ranges between three and ten inches, depending on elevation. Lower values of this range are typical in valleys, whereas higher values are typical in the surrounding mountains.

2.4 TEMPERATURE

Elevation influences temperatures on the NTS, with higher elevations having a higher sustained cooler temperature and the lower elevations having a higher sustained warmer temperature.

At an elevation of 2,000 m (6,560 ft) Pahute Mesa recorded a maximum temperature in 2000 of 39 °C (102 °F) and a minimum temperature of -11 °C (11 °F). The average maximum temperature was 16 °C (61 °F) and the average minimum was 5 °C (41 °F). In the Yucca Flat

basin at an elevation of 1,195 m (3,920 ft), the maximum temperature recorded for 2000 was 48 °C (118 °F) and the minimum temperature was -13 °C (8 °F). The average maximum temperature was 23 °C (73 °F) and the average minimum was 3 °C (38 °F).

2.5 WIND

Winds are primarily southerly during summer months and northerly during winter months. Wind velocities tend to be greater in the spring than in the fall. At the Yucca Playa station, the average annual wind velocity was 11 kph (7 mph); the maximum wind velocity was nearby at the Meteorological Data Acquisition System Station 4 at 137 kph (85 mph). At Area 20 Camp on Pahute Mesa, the average annual wind velocity was 16 kph (10 mph) miles per hour; the maximum wind velocity was 83 kph (52 mph). The multi-year wind roses for selected locations around the NTS are shown in Figure 2.3.

2.6 EVAPORATION

Evaporation at the NTS is high in the flats (Frenchman, Yucca, and Jackass) because of the large incident solar radiation and wind. Potential evaporation is evaporation at a potential, or energy-limiting rate; it is calculated using any of a number of available equations. The potential evaporation usually exceeds ten times the annual precipitation on the valleys of the NTS.

2.7 GEOLOGY

The NTS is located in the south central part of the Great Basin section of the Basin and Range physiographic province. The topography of this province is characterized by north- to northeast-tending mountain ranges, separated by broad, linear valleys and is evident on the eastern portion of the NTS. In the vicinity of the NTS, this series of ridges and valleys is locally disrupted by a large volcanic plateau and an associated complex of overlapping collapse calderas.

During the Paleozoic Era, the NTS region was part of the Cordilleran miogeosyncline, a subsiding trough on the submerged western edge of the North American continent. This miogeosyncline, extending from Mexico to Alaska, received thousands of feet of shallow water deposition, derived from erosion of the nearby continental land mass. As a result, in excess of 30,000 feet of Paleozoic clastic and carbonate rocks was deposited in the NTS region. During the Mesozoic Era, these rocks were complexly folded and thrust faulted in several periods of compressional deformation. The CP Thrust and the Mine Mountain Thrust are the major thrust faults formed during this time in the NTS region. These episodes of mountain building were accompanied by intrusions of granitic plutons, which are represented by the Climax, Twin Ridge, and Gold Meadows stocks on the NTS.

A major period of silicic volcanism began in the central portion of the Great Basin approximately 40 million years ago and spread outward through time. The dominant volcanic activity in the NTS region began about 16 million years ago and continued at least until 0.25 million years ago. A complex of six collapse calderas, five of which overlap, was active along the western portion of the NTS between 16 and 6 million years ago. Ash flow tuffs that erupted from these centers exceed 15,000 ft thickness under Pahute Mesa, a volcanic plateau in the northwestern portion of the NTS. A transition to basalt eruptions occurred approximately six million years ago.

The crustal extension which produced north- to northeast-tending normal faults began between 17 and 14 million years ago in southern Nevada. Uplift and subsidence along these faults resulted in the present-day system of mountain ranges and topographically closed basins.

Alluvium and colluvium from the mountain ranges have filled the basins to depths of several hundred meters or more.

Refer to Chapter 7.0 of this report for a detailed overview of the geology of the NTS.

2.8 HYDROGEOLOGY

Depths to groundwater under the NTS vary from about 210 m (690 ft) beneath the Frenchman Flat playa (Winograd and Thordarson 1975) in the southern part of the NTS to more than 700 m (2,300 ft) beneath part of Pahute Mesa. In the eastern portions, the water table occurs generally in the alluvium and volcanic rocks above the regional carbonate aquifer and is characterized by regional flow from the upland recharge area in the north and east, towards discharge areas at Ash Meadows and Death Valley. In the western portion of the NTS, the water table occurs predominantly in volcanic rocks and moves in a southerly direction toward Oasis Valley, Crater Flat, and/or western Jackass Flats.

Groundwater is the only local source of drinking water in the NTS area. Drinking and industrial water supply wells for the NTS produce from the lower and upper carbonate aquifers and the volcanic and the valley-fill aquifers. Although a few springs emerge from perched groundwater lenses at the NTS, discharge rates are low, and spring water is not used for NNSA/NV activities. North and south of the NTS, private and public supply wells are completed primarily in a valley-fill aquifers.

2.9 ECOLOGY

The NTS is between the northern boundary of the Mojave Desert and the southern limits of the Great Basin Desert. This “Transitional Desert” includes vegetation associations of both deserts. Communities of the Mojave Desert occur over the southern third of the NTS, on bajadas and mountain ranges at elevations below about 4,000 feet. They are limited to areas with mean annual minimum temperatures greater than 28^{o} F and mean annual precipitation less than 7.2 inches (O’Farrell and Emery 1976.) Mojave Desert communities can have highly variable floristic compositions, but all are dominated by creosote bush (*Larrea tridentata*) and variable co-dominant shrubs. Shrub coverage varies from 7 to 23 percent for Mojave Desert communities on the NTS (Beatley 1976.) Above 5,000 feet, the vegetation mosaic begins to be dominated by sagebrush associations of *Artemisia tridentata* and *Artemisia arbuscula* subspecies *nova*. Above 6,000 feet, piñon pine and juniper mix with the sagebrush associations, where there is suitable moisture for these trees.

Most mammals on the NTS are small and often nocturnal in habitat, hence not often seen by casual observers. Rodents are the most important group of mammals on the NTS, based on distribution and relative abundance. Larger mammals include feral horses, mule deer, mountain lions, bobcats, coyote, kit foxes, and rabbits, among others. Among other taxa, the reptiles include the desert tortoise, over 12 lizards, and 17 snakes; 4 of which are venomous. Bird species are mostly migrants or seasonal residents. Most nonrodent mammals have been placed in the "protected" classification by the state of Nevada. The Mojave population of the desert tortoise, *Gopherus agassizii*, is listed as threatened by the U.S. Fish and Wildlife Service. The habitat of the desert tortoises on the NTS is found in its southern third, outside the recent areas of nuclear explosives test activities.

2.10 CULTURAL RESOURCES

Human habitation of the NTS area began at least as early as 10,000 years ago. Various indigenous cultures occupied the region in prehistoric times. The survey of less than 5 percent of the NTS area has located more than 2,000 archaeological sites, which contain the only information available concerning the prehistoric inhabitants. The site types identified include rock quarries, tool-manufacturing areas, plant-processing locations, hunting locales, rock art, temporary camps, and permanent villages. The prehistoric people's lifestyle was sustained by a hunting and gathering economy, which utilized all parts of the NTS.

While major springs provided perennial water, the prehistoric people developed strategies to take advantage of intermittent fresh water sources in this arid region. In the nineteenth century, at the time of initial contact, the area was occupied by Paiute and Shoshone Indians. Prior to 1940, the historic occupation consisted of ranchers, miners, and Native Americans. Several natural springs were able to sustain livestock, ranchers, and miners. Stone cabins, corrals, and fencing stand today as testaments to these early settlers. The mining activities included two large mines: one at Wahmonie, the other at Climax Mine. Prospector claim markers are found in these and other parts of the NTS. Cane Springs was the last mining boom town in Nevada and was a sizeable town in the years 1929 and 1930. Native Americans coexisted with the settlers and miners, utilizing the natural resources of the region and, in some cases, working for the new arrivals. They also maintained a connection with the land, especially areas important to them for religious and historical reasons. These locations, referred to as traditional cultural properties, continue to be significant to the Paiute and Shoshone Indians.

2.11 NTS NUCLEAR TESTING HISTORY

Between 1940 and 1950, the area now known as the NTS was under the jurisdiction of Nellis Air Force Base and was part of the Nellis Bombing and Gunnery Range. The NTS was established in 1951 as the primary location for testing the nation's nuclear explosive devices. Tests conducted through the 1950s were predominantly atmospheric tests. These tests involved a nuclear explosive device detonated while on the ground surface, on a steel tower, suspended from tethered balloons, or dropped from an aircraft. Several tests were categorized as "safety" experiments, including transport and storage tests, involving the destruction of a nuclear device with nonnuclear explosives. Some of these tests resulted in dispersion of plutonium in the test vicinity. One of these test areas lies just north of the NTS boundary, and four others, involving transport/storage safety, lie at the north end of the NAFR. All nuclear device tests are listed in DOE/NV Report NV-209 (DOE 2000b).

The first underground test, a cratering test was conducted in 1951. The first test totally contained underground was in 1957. Testing was discontinued during a moratorium that began October 31, 1958, but was resumed in September 1961, after tests by the Union of Soviet Socialist Republics began. Since late 1962, nearly all tests have been conducted in sealed vertical shafts drilled into Yucca Flat and Pahute Mesa or in horizontal tunnels mined into Rainier Mesa. Five earth-cratering (shallow-burial) tests were conducted over the period of 1962 through 1968 as part of the Plowshare Program, that explored peaceful uses of nuclear explosives. The first and largest Plowshare crater test, SEDAN (PHS 1963) was detonated at the northern end of Yucca Flat. There have been no United States nuclear explosive tests since September 1992.

Other nuclear testing history at the NTS has included the Bare Reactor Experiment - Nevada series in the 1960s. These tests were performed with a 14-MeV neutron generator mounted on a 465-m (1,530-ft) steel tower, used to conduct neutron and gamma-ray interaction studies on various materials. From 1959 through 1973, a series of open-air nuclear reactor, nuclear engine, and nuclear furnace tests was conducted in Area 25, and a series of tests with a nuclear ramjet engine was conducted in Area 26.

2.12 SURROUNDING AREAS

Figure 2.4 is a map of the offsite area showing a variety of lands uses and the various governmental agencies responsible for managing the land. The lands, with the exception of the Department of Defense and NNSA/NV, are open to a wide variety of uses such as farming, mining, grazing, camping, fishing and hunting, within a 300-km (180-mi) radius of the Control Point-1.

2.13 DEMOGRAPHY

The population of the area surrounding the NTS has been estimated by the Nevada State Demographer Office and is predominantly rural. Nevada annual population estimate for Nevada Counties, Cities, and Unincorporated Towns is 2,066,831, with all but 641,108 residing in Clark County. Excluding Clark County, the major population center, the population density within a 150-km (90-mi) radius of the NTS is about 0.5 persons/km^2. In comparison, the 48 contiguous states (1990 census) had a population density near 29 persons/km^2. Several small communities are located in the area (populations in parenthesis), Alamo (507), Amargosa (1,271), Beatty (1,255), Goldfield (574), Indian Springs (1,387), Pahrump (26,399), and Tonopah (3,086). The largest of these communities being Pahrump Valley approximately 50 mi (80 km) south of the NTS Control Point (CP-1), which is near the center of the NTS.

The Mojave Desert of California, which includes Death Valley National Monument, lies along the southwestern border of Nevada. This area is still predominantly rural; however, tourism at Death Valley National Park swell the population over 5,000 on any particular day during holiday periods during mild weather.

The extreme southwestern region of Utah is more developed than the adjacent portion of Nevada. The largest community is St. George, located 220 km (137 mi) east of the NTS, with a population of 29,000. The next largest town, Cedar City, with a population of 14,000, is located 280 km (174 mi) east-northeast of the NTS.

The extreme northwestern region of Arizona is mostly rangeland, except for that portion in the Lake Mead recreation area. In addition, several small communities lie along the Colorado River. The largest towns in the area are Bullhead City, 165 km (103 mi) south-southeast of the NTS, with a population estimate of 22,000, and Kingman, located 280 km (174 mi) southeast of the NTS, with a population of about 13,000.

2.14 MISSION AND NATURE OF OPERATIONS

The present mission of the NNSA/NV is described by the following five statements:

- **National Security:** support the Stockpile Stewardship Program through subcritical and other weapons physics experiments, emergency management, test readiness, work for other national security organizations, and other experimental programs.

- **Environmental Management:** support environmental restoration, groundwater characterization, and low-level radioactive waste management.

- **Stewardship of the NTS:** manage the land and facilities at the NTS as a unique and valuable national resource.

- **Technology Diversification:** support nontraditional Departmental programs and commercial activities which are compatible with the Stockpile Stewardship Program.

- **Energy Efficiency and Renewable Energy:** support the development of solar energy, alternative fuel, and energy efficiency technologies.

2.15 STOCKPILE STEWARDSHIP

There were five subcritical experiments which involved small amounts of special nuclear material that do not reach the fissioning stage during the experiment. In addition, 30 experiments were conducted at the BEEF and construction was completed on JASPER.

2.16 ENVIRONMENTAL MANAGEMENT

The Environmental Restoration efforts included remediating 50 industrial sites. The Underground Test Area program drilled three holes and continued work on modeling efforts.

Approximately 650,000 cubic feet of low-level waste was disposed of at the Area 3 and Area 5 Radioactive Waste Management Sites (475 shipments). In addition, 195 drums of transuranic waste were processed prior to shipment to the WIPP in New Mexico.

2.17 HAZARDOUS MATERIALS SPILL CENTER (HSC)

The NNSA/NV's HSC is a research and demonstration facility available on a user-fee basis to private and public sector test and training sponsors concerned with the safety aspects of hazardous chemicals. The site is located in Area 5 of the NTS and is maintained by Bechtel Nevada. The HSC is the basic research tool for studying the dynamics of accidental releases of various hazardous materials. The facility was active for 37 weeks in Calendar Year 2000.

Rainier Mesa (No Date Provided)

3.0 COMPLIANCE SUMMARY

Environmental compliance activities at the Nevada Test Site (NTS) during calendar year (CY) 2000 involved the permitting and monitoring requirements of numerous state of Nevada and federal regulations. Primary activities included the following: (1) National Environmental Policy Act (NEPA) documentation preparation; (2) Clean Air Act (CAA) compliance for asbestos renovation projects, radionuclide emissions, and state air quality permits; (3) Clean Water Act (CWA) compliance involving state wastewater permits; (4) Safe Drinking Water Act (SDWA) compliance involving monitoring of drinking water distribution systems; (5) Resource Conservation and Recovery Act (RCRA) management of hazardous wastes; (6) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) reporting; (7) Toxic Substances Control Act (TSCA) management of polychlorinated biphenyls; (8) Endangered Species Act (ESA) compliance involving the conduct of pre-construction and site-wide surveys to document the status of state and federally listed endangered or threatened plant and animal species; and (9) National Historic Preservation Act (NHPA) compliance for the protection of Cultural and Native American Resources. There were no activities requiring compliance with Executive Orders (EOs) on Flood Plain Management or Protection of Wetlands.

Throughout CY 2000 the NTS was subject to several formal compliance agreements with various regulatory agencies. Agreements with Nevada include a Memorandum of Understanding covering releases of radioactivity; a Federal Facilities Agreement and Consent Order (FFACO), an Agreement in Principle covering environment, safety, and health activities; a Settlement Agreement to manage mixed transuranic (TRU) waste; and a Mutual Consent Agreement on management of mixed land disposal restriction (LDR) wastes, among others. Emphasis on pollution prevention and waste minimization at the NTS continued in 2000.

Compliance activities at non-NTS facilities of the National Nuclear Security Administration Nevada Operations Office (NNSA/NV) involved the permitting and monitoring requirements of (1) the CAA for airborne emissions, (2) the CWA for wastewater discharges, (3) SDWA regulations, (4) RCRA disposal of hazardous wastes, and (5) hazardous substance reporting. Pollution prevention and waste minimization efforts continued at all locations.

3.1 COMPLIANCE STATUS

NATIONAL ENVIRONMENTAL POLICY ACT

Rulings by the Council on Environmental Quality, "Regulations of the National Environmental Policy Act" [40 Code of Federal Regulations (CFR) 1500 - 1508] require federal agencies to consider environmental effects and values and reasonable alternatives before making a decision to implement any major federal action that may have a significant impact on the human environment.

Since November 1994, NNSA/NV has had full delegation of authority from the U.S. Department of Energy Headquarters (DOE/HQ) for Categorical Exclusion (CX) Determinations, Environmental Assessments (EAs), issuing Findings of No Significant Impact, and floodplain and wetland action documentation related to NNSA/NV proposed actions.

The NNSA uses three levels of documentation to demonstrate compliance with NEPA: (1) an Environmental Impact Statement (EIS) is a full disclosure of the potential environmental effects of proposed actions and the reasonable alternatives to those actions; (2) an EA is a concise discussion of a proposed action and alternatives and the potential environmental effects to determine if an EIS is necessary; and (3) a CX is used for classes of action which have been found to have no adverse environmental impacts, based on similar previous activities. NNSA/NV activities involved only CXs and EAs during CY 2000.

Completion of a NEPA Environmental Evaluation Checklist is required under the NNSA/NV Work Acceptance Process Procedural Instructions (Carlson 2000) for all proposed projects or activities. The Checklist is reviewed by the NNSA/NV NEPA Compliance Officer to determine whether the project or activity is included in the NTS/EIS and record of decision (ROD) or other previously completed NEPA analysis. During CY 2000, checklists were completed for 60 proposed projects or activities at the NTS. Seventeen of these 60 were exempted from further NEPA analyses by being a CX; 38 were exempted due to previous analysis in the NTS/EIS and ROD; four were exempted due to previous NEPA analysis and determinations in EA's; and one required further NEPA analysis, i.e., an EA. The EA for Temporary Storage of Fuel for the Sandia Pulsed Reactor was subsequently canceled on March 12, 2000. An EA for a proposed Alternative Energy Generation Facility, to be located in various Areas at the NTS, was initiated in 2000 and is still in progress.

Still pending is the following document developed by or with NNSA/NV involvement:

- Kistler Aerospace Corporation in Areas 18 and 19 EA.

CLEAN AIR ACT (CAA)

The CAA and the state of Nevada air quality control compliance activities were limited to asbestos abatement, radionuclide monitoring, reporting under the National Emission Standards for Hazardous Air Pollutants (NESHAP), and air quality permit compliance requirements. There were no criteria pollutant or prevention of significant deterioration monitoring requirements for NTS operations.

NTS NESHAP Asbestos Compliance

The state Division of Occupational Safety and Health regulations (Nevada Administrative Code [NAC] 618.850, 1989) require that all asbestos abatement projects in Nevada, involving friable asbestos in quantities greater than or equal to three linear feet or three square feet, submit a Notification Form. Notifications are also required to be made to the U.S. Environmental Protection Agency (EPA) Region 9 for projects which disturb greater than 260 linear ft or 160 ft^2 of asbestos-containing material, in accordance with Title 40 CRF 61.145-146 (CFR 1989).

During 2000, there were no projects that required state of Nevada notifications be made. The annual estimate for non-scheduled asbestos demolition/renovation for fiscal year (FY) 2000 was sent to EPA Region 9 on December 13, 1999.

Radioactive Emissions on the NTS

NTS operations were conducted in compliance with the NESHAP radioactive air emission standards of Title 40 CFR 61, Subpart H. In compliance with those requirements, a report on airborne radioactive effluents is provided to DOE/HQ and to EPA's Region 9.

There are two locations on the NTS where airborne radioactive effluents may be emitted from permanent stacks: (1) the tunnels in Rainier Mesa, and (2) the analytical laboratory hoods in the community of Mercury. Based on the amount of radioactivity handled, the exhaust from the analytical laboratories is considered negligible compared to other sources on the NTS and the tunnels have been sealed (although water still seeps from one). Present sources are evaporation of tritiated water (HTO) from containment ponds, diffusion of HTO vapor from the Area 5 Radioactive Waste Management Site (RWMS-5), the SEDAN test in Area 10, the SCHOONER test in Area 20, and resuspension of plutonium contaminated soil from nuclear device safety test and atmospheric test locations.

In the CY 2000, NTS NESHAP report for airborne radioactive effluents (Grossman 2001), airborne emission of HTO vapor from the containment ponds was conservatively reported as if all the liquid discharge into the ponds had evaporated and become airborne. For HTO vapor diffusing from the RWMS-5, SEDAN, and SCHOONER, and plutonium/americium particulate resuspension from various areas on and near the NTS, the airborne effluents were conservatively estimated.

Using these conservative estimates of air emissions, the effective dose equivalent reported for CY 2000 was calculated to be only 0.17 mrem (1.7×10^{-3} mSv), much less than the 10-mrem limit that is specified in Title 40 CFR 61.

NTS Air Quality Permit Compliance

Compliance with air quality permits is accomplished by adhering to record keeping and reporting requirements and through renewal and ongoing verification of operational compliance with permit-specified limitations. A list of active NTS air quality permits appears in Table 3.1. Common air pollution sources at the NTS include aggregate production, surface disturbances, fugitive dust from unpaved roads, fuel burning equipment, open burning, and fuel storage facilities.

Quantities of emissions from operations at the NTS are calculated and submitted each year to the state of Nevada using forms provided by the state. The report also includes aggregate production amounts, operating hours of permitted equipment, and surface disturbance information for all disturbances of five acres or greater. During 2000, approximately 14 tons of pollutants were estimated to be emitted from permitted operations at the NTS. The Air Quality Permit Data Report was sent to the state of Nevada in February 2000.

One of the conditions of the permit is to allow state of Nevada Bureau of Air Quality personnel access to the NTS to conduct inspections of facilities and operations regulated by state air permits. During 2000, there were no state inspections of NNSA/NV facilities possessing air quality permits.

Monthly visible emissions readings are a requirement of the NTS air quality operating permit, AP9711-0549. The permit limits particulate emissions to 20 percent opacity, except at the Area 1 Aggregate Plant, where portions of the Plant have a limit of 10 percent. Certification of personnel to perform valid visible emission opacity evaluations is required by the state, with recertification required every six months. During 2000, two employees from Bechtel Nevada (BN) were recertified, and several visible emission evaluations of permitted air quality point sources were conducted. The opacity limit was not exceeded in 2000.

Non-NTS Air Quality Permit Compliance

Under normal conditions, the six non-NTS facilities operated by the NNSA/NV do not produce radioactive effluents. The six are, the North Las Vegas Facility (NLVF) and Remote Sensing Laboratory (RSL) at Nellis Air Force Base in North Las Vegas, Nevada; Special Technologies Laboratory (STL) in Santa Barbara, California; Livermore Operations (LO) in Livermore, California; Los Alamos Operations (LAO) in Los Alamos, New Mexico; and RSL Andrews Air Force Base in Washington, D.C. The NLVF and RSL facilities in North Las Vegas are regulated for the emission of criteria pollutants and maintain air quality operating permits for a variety of equipment that mainly includes boilers and generators (Table 3.2). Twelve air quality operation permits and two dust permits, issued by the Clark County Health District in Las Vegas, Nevada, were required for operations at the NLVF and RSL during 2000. There were no effluent monitoring requirements associated with these permits.

No air permits were held or required for the LO, LAO, or RSL-Andrews facilities in 2000.

CLEAN WATER ACT (CWA)

The Federal Water Pollution Control Act, as amended by the CWA, establishes ambient water quality standards and effluent discharge limitations which are generally applicable to facilities that discharge any materials into the waters of the United States (CFR 1977). Discharges from NNSA/NV facilities are primarily regulated under the laws and regulations of the facility host states. Monitoring and reporting requirements are typically included under state or local permit requirements. A list of applicable permits appears in Tables 3.3, 3.4, and 3.5. There are no National Pollutant Discharge Elimination System permits for the NTS, as there are no wastewater discharges to onsite or offsite surface waters.

NTS Operations

Discharges of wastewater are regulated by the state under the Nevada Water Pollution Control Law (Nevada Revised Statutes 1977). The state of Nevada also regulates the design, construction, and operation of wastewater collection systems and treatment works. Wastewater monitoring at the NTS was limited to sampling wastewater influents to sewage lagoons and containment ponds.

State general permit GNEV93001 (Table 3.3), which regulates the ten usable sewage treatment facilities on the NTS, was issued by the Nevada Division of Environmental Protection (NDEP) and became effective on February 1, 1994. The general permit was renewed for five years on December 7, 1999. The permit was structured to allow The NNSA more flexibility in bringing new industrial processes on line.

Downsizing of NTS operations has resulted in low flow conditions at sewage lagoon systems servicing the Area 5 RWMS, Area 12 Camp, Area 25 Central Support Facility, Area 25 Reactor Control Point, and Area 6 Los Alamos National Laboratory. Automated flow meters are subject to incorrect flow measurements at low flow rates; therefore, a system was tested this year which incorporated a tipping bucket and timer. This system proved effective for accurate flow measurements in low flow situations. The use of this measuring system was noted in the Quarterly Discharge Monitoring Reports submitted to the state.

In the second quarter of 2000, the Operations and Maintenance Plan for the NTS sewage lagoons was updated and transmitted to NDEP for approval. In August, the state approved the plan, with comments. Also during this quarter, the Area 6 Device Assembly Facility (DAF) sewage lagoon influent exceeded the pH limit of 9.0 by 0.1 pH units (reported as 9.1). An investigation revealed no unusual circumstances or processes which could contribute to this exceedence. Supply water from wells serving the DAF typically have a pH of 8.5 - 8.8, and therefore already exhibit a high pH. Results of the investigation were reported to NDEP.

During the third Quarter of 2000, the NNSA requested a waver from administrative controls for the Area 25 Central Support Area sewage lagoon. Declining worker population at this site had reduced the flow and subsequent reporting parameters for administrative controls. Relief was granted by NDEP, with conditions, should the population increase again.

During the fourth Quarter of 2000, the NNSA proposed that the monitoring requirements for low flow systems be changed. The NNSA proposed not to sample lagoons that have less than 30 cm of sewage accumulated in their primaries. No response was received from NDEP by the close of the year. A response is expected in 2001.

There were no formal state inspections of the sewage lagoons in 2000.

In May of 2000, the NNSA inspected Area 25 facilities to meet the “administrative controls” requirements in the permit for industrial discharges. All facilities and operations were determined to be in compliance.

Non-NTS Operations

Three permits for wastewater discharges were held by non-NTS facilities. One permit is required for the NLVF, and the STL holds wastewater permits for the Botello Road and Ekwill Street locations (Table 3.3). No wastewater permits were required for the LO, LAO, or RSL-Andrews facilities in 2000.

The Wastewater Contribution Permit for NLVF (VEH-112) was renewed in 1999, with an effective date of January 1, 2000. In October 2000, the city of North Las Vegas removed monitoring requirements for mercury, organophosphorus or carbamate compounds, selenium, arsenic, and beryllium from VEH-112.

SAFE DRINKING WATER ACT (SDWA)

NTS Operations

The Safe Drinking Water Act and state of Nevada regulations (NAC 445A) constitute the basis for drinking water compliance at the NTS. The state of Nevada has enforcement authority for the SDWA and has promulgated regulations covering operation and maintenance, water haulage, operator certification, permitting, and SDWA monitoring requirements.

BN operates four public water systems at the NTS (Table 3.4). Permits are renewed annually in September. The water systems are monitored for coliform bacteria, volatile organic chemicals, inorganic chemicals, synthetic organic compounds, and other water quality parameters on a schedule established by the state of Nevada in accordance with federal requirements.

In 2000, the four systems were in compliance with SDWA monitoring requirements, with one exception. During 2000, lead was found above the action level in one system. Corrective action was initiated to resolve this problem (see Chapter 6.0 for details). All other monitoring results for 2000 were within regulatory limits and are discussed in Chapter 6.0. The cross-connection control program at the NTS is not well-documented, and NNSA/NV was not able to complete a Cross-Connection Control Plan, as required by state regulation. An engineering study has been commissioned and steps have been taken to correct the record-keeping deficiencies.

NTS Water Haulage

To accommodate the diverse and often transient field work locations at the NTS, a water haulage program is used. To ensure potability of hauled water, permitted water hauling trucks use a sanitary connection to obtain and deliver potable water from a permitted water system. In 2000, the NTS maintained three permitted water hauling trucks. Water hauling permits are renewed annually at the same time as the regular water system permits (Table 3.4).

Water hauling trucks are sampled monthly for coliform bacteria. One of the trucks had one positive coliform bacteria sample in 2000. Detailed information appears in Chapter 6.0.

Non-NTS Operations

All non-NTS operations receive municipal water and have no compliance activities under the SDWA and state/local regulations.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

RCRA (RCRA 1976) and the Hazardous and Solid Waste Amendments of 1984 constitute the statutory basis for the regulation of hazardous waste and underground storage tanks (USTs). Under Section 3006 of RCRA, the EPA may authorize states to administer and enforce hazardous waste regulations. Nevada has received such authorization and acts as the primary regulator for many NNSA/NV facilities. The Federal Facilities Compliance Act (FFCA) of 1992 extends the full range of enforcement authorities in federal, state, and local laws for management of hazardous wastes to federal facilities, including the NTS.

NTS RCRA Compliance

In 2000, NNSA/NV received a new RCRA Hazardous Waste Operating Permit for the Area 5 Hazardous Waste Storage Unit (HWSU) and the Area 11 Explosive Ordnance Disposal Unit.

In 2000, NNSA/NV let expire a RCRA Research Development and Demonstration Permit for the construction and operation of the Tactical Demilitarization Development (TaDD) facility. This facility will develop treatment methods for deactivating waste missiles. The NNSA will reapply for this permit upon project initiation.

HAZARDOUS WASTE REPORTING FOR NON-NTS OPERATIONS

The LO, STL, and LAO locations generate hazardous waste and have EPA Identification numbers, but have no reporting requirements because they are operated as conditionally exempt small quantity generators of hazardous waste.

UNDERGROUND STORAGE TANKS (USTs)

NTS Operations

The NTS UST program has met regulatory compliance schedules for the reporting, upgrading, or removal of documented USTs. During 2000, there were no regulated USTs removed or upgraded, as all requirements had been satisfied in 1998.

The NNSA/NV operates one deferred UST and three excluded USTs at the DAF. The NNSA/NV also maintains a fully-regulated UST that is not currently in service at the Area 6 heli-pad.

The NTS also has 12 unregulated underground heating oil tanks. In CY 2000, one tank was upgraded with spill protection and four tanks were upgraded with spill and overfill protection. Impacted soil from historic spills around four of the tank fill ports was remediated. One of the spill sites was administratively closed in place because removal of impacted soil would have affected essential services.

Non-NTS Operations

The RSL operates three fully-regulated USTs, one deferred UST, and two excluded USTs. All are in compliance with the regulations.

COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA)/SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA)

In April 1996, the NNSA/NV, Department of Defense, and the NDEP entered into a FFACO pursuant to Section 120(a)(4) of CERCLA (CERCLA 1980) and Sections 6001 and 3004(u) of RCRA (RCRA 1976) to address the environmental restoration of historic contaminated sites at the NTS, parts of Tonopah Test Range (TTR), parts of the Nellis Air Force Range (NAFR), the Central Nevada Test area, and the Project SHOAL area. Appendix VI of the FFACO describes the strategy that will be employed to plan, implement, and complete environmental corrective action at facilities where nuclear-related operations were conducted.

FEDERAL FACILITIES AGREEMENT AND CONSENT ORDER (FFACO)

Remedial Activities - Surface Areas

Environmental restoration activities continued at the NTS and TTR in FY 2000. These activities comply with the agreements specified in the FFACO signed between the NNSA/NV and the NDEP and follow a formal work process beginning with a Data Quality Objectives (DQO) meeting between NNSA, NDEP, and contractors. The purpose of the DQO meeting is to define the scope of work, how the site characterization is to be done (sampling strategy), and to develop the conceptual model for the site. The conceptual model defines the nature and extent of waste in the subsurface and guides the investigation. A Corrective Action Investigation Plan is prepared, providing the information on how the site is to be characterized.

Site characterization is carried out and documented in the Corrective Action Decision Document (CADD). This report provides the information that either confirms the conceptual model or modifies it. If suitable information is available to make a decision, a remedial alternative is selected from several alternatives identified for analysis that best provides site closure. In some instances, additional site characterization may be required before the CADD can be prepared.

If a site requires remediation, a Corrective Action Plan (CAP) is prepared that provides the necessary design and other information on the method of remediation. A CAP includes the proposed methods to be used to close a site, quality control measures, waste management strategy, design drawings (when appropriate), verification sampling strategies (for clean closures) and other information necessary to perform the closure. Some sites also require a Post Closure Plan as the site or parts of the site are closed in place. Information on inspections and monitoring are provided in an Annual Post Closure Monitoring Report.

Once the closure has been completed, a Closure Report is prepared. This report provides information on the work performed, results of verification sampling, as-built drawings (if appropriate), waste management, etc.

The NDEP is a participant throughout the remediation process. The Community Advisory Board is also kept informed by NNSA/NV of the progress made.

Some sites are closed under the Streamlined Approach for Environmental Restoration (SAFER) process. These sites typically have suitable information available and can be remediated under a shorter schedule. A SAFER plan is prepared providing the methods to be used to close the site. After closure, a SAFER closure report is prepared that documents the work performed.

During 2000 all FFACO deadlines were met. The actions taken are summarized below:

- Annual Post Closure Monitoring Reports were submitted to comply with the conditions of the RCRA Part B Permit for the Area 2 Bitcutter Shop and Lawrence Livermore National Laboratory (LLNL) Post Shot Containment Building Injection Wells (corrective action unit [CAU] 90), Area 23 Landfill Hazardous Waste Trenches (CAU 112), U3fi Injection Well (CAU 91), and Area 6 Decontamination Pond (CAU 92) RCRA Closure Units.

- Several other CAUs also had post closure monitoring reports prepared. These were the Area 12 Steam Fleet Operations Steam Cleaning Discharge Area (CAU 339), Roller Coaster Sewage Lagoons, TTR (CAU 404), Cactus Springs Waste Trenches, TTR (CAU 426), Area 3 Septic Waste Systems 2 and 6, TTR (CAU 427), and Area 9 UXO Landfill, TTR, (CAU 453).

- The closure plan for the U3ax/bl Subsidence Crater was prepared and approved by NDEP. The plan discusses the use of a monolayer evapotranspiration cover that takes advantage of the low precipitation and high evapotranspiration at the NTS. Closure is to be done during the first quarter of fiscal year 2001.

- The DOUBLE TRACKS Radsafe Area site (CAU 486) was closed and the draft closure report prepared.

- The Area 25 Building 4839 Leachfield (CAU 263) was closed.

- The CAP for the ROLLER COASTER Radsafe Area (CAU 407) in TTR was prepared and the site closed.

- Preparation of the draft CAP for the Area 25 Waste Dumps (CAU 143) began.

- The Area 25 Storage Tanks (CAU 135) CAP was prepared and approved by the NDEP. The site was also closed.

- The Area 25 Vehicle Wash Down Sites (CAU 240) CAP was prepared and the site closed. Preparation of the draft closure report began.

- The closure report for the NTS Pesticide Release Site (CAU 340) was prepared and sent to the NDEP.

- The CAU 232, Area 25 Sewage Lagoons was closed.
- The Sectored Clean-Up Work Plan for Housekeeping Sites was prepared and sent to the NDEP. This document will allow removal of housekeeping waste without preparation of a plan for each CAU.
- Housekeeping CAU 345 (Areas 2 and 9 Housekeeping) was closed and a draft closure report prepared.
- Housekeeping CAU 524, (Areas 25, 6, 12, and 19 Housekeeping Waste) was closed and a closure report prepared.
- The closure report for CAU 342, Area 23 Mercury Fire Training Pit was prepared and sent to the NDEP.
- The corrective action investigation plan (CAIP) for CAU 261, Area 25 R-MAD Contaminated Leachfields was prepared and sent to the NDEP.
- CAU 321, Area 2 Weather Station Fuel Storage was characterized and a CADD and CAP were prepared and sent to the NDEP. Closure activities began but required rescoping when it became apparent that additional characterization was required.
- The Area 3 Septic Waste Systems 1 and 5, TTR (CAU 428) was characterized and a CADD and CAP were prepared and sent to the NDEP.
- The CADD for CAU 261, Area 25 Test Cell A Leachfield System was prepared and sent to the NDEP. The CAP for was prepared and sent to the NDEP.
- CAU 230, Area 22 Sewage Lagoons and CAU 320, Area 22 Desert Rock Airport Strainer Box site were characterized. The CADD and CAP were prepared and sent to the NDEP.
- The Draft White Paper on Deactivation and Decomposing (D&D) Activity for FY 2000 Accomplishments was prepared and distributed.
- The D&D Surveillance and Maintenance Activities Master Plan, NTS was prepared and distributed.
- Preparation of the SAFER Work Plan for CAU 113, R-MAD began.
- The CAIP for the Station 44 Burn Area, TTR (CAU 490) was prepared and sent to the NDEP. The site was characterized and a CADD prepared and sent to the NDEP.
- The CADD for the Area 25 R-MAD Decontamination Facility (CAU 254) was prepared and sent to the NDEP. Preparation of the CAP began.
- CAU 409, other Waste Sites CAIP was prepared and sent to the NDEP.
- CAU 329, Area 22 Desert Rock Airstrip Fuel Spill was closed and a SAFER Closure Report sent to the NDEP.
- CAU 417 of the Central Nevada Test Area was closed. The CAP was prepared and sent to the NDEP.

EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT (EPCRA)

EPCRA compliance activities for 2000 included upgrading of the inventory system to accommodate intranet data submittal, improved reporting, and standardization of hazard classifications for chemicals reported.

In March 2000, the Nevada Combined Agency Report was submitted to the state Fire Marshall's office by NNSA/NV. EPCRA compliance with Section 302 (Planning Notification) and Sections 311-312 (Material Safety Data Sheet/Chemical Inventory) for the NTS, Hazardous Materials Spill Center (HSC), NLVF, and the RSL was met. No planning thresholds were exceeded at these facilities. Chemical Catastrophe Prevention Program requirements were also met for these facilities. The latter program covers extremely hazardous substances (EHSs).

A Toxic Release Inventory Report required by Section 313 of the SARA Title III must be provided if the facility, any time in the prior CY, exceeds any section 313 threshold for manufacture, process, or other use. In CY 1999, no thresholds were exceeded, so no report was required in 2000.

Non-NTS Tier II Reporting Under SARA Title III

The reports for the off-NTS Nevada facilities, RSL and NLVF, are described under EPCRA above.

Other non-Nevada operations either had no chemicals above reporting thresholds or submitted their chemical inventories to the cities/counties as part of their business plans.

DOE ORDER 435.1 RADIOACTIVE WASTE MANAGEMENT

In June of 2000, NNSA/NV prepared an Implementation Plan to meet the DOE Order 435.1 requirements. This implementation plan established a compliance schedule for the development of a Site Specific Manual, identification of facilities and activities subject to 435.1, and the development of an integrated Sitewide Radioactive Waste Management Program (SWRWMP) requiring full implementation by March 5, 2001. A manual (NV M435.1-1) was issued in August 2000 that established an integrated SWRWMP and the basis for the management of radioactive waste (i.e., low-level, transuranic, and mixed low-level) under the responsibility of NNSA/NV. The Office of the Assistant Manager for Environmental Management (AMEM) was granted responsibility for this Program.

This Manual authorized creation of an AMEM-appointed panel called the Radioactive Waste Management Basis Assistance and Review Team (RWMBART). The RWMBART, as chaired by the Division Director, Waste Management Division, is an independent team comprised of representatives from NNSA/NV and various contractors. RWMBART responsibilities include guidance and review of technical elements to support full compliance with the requirements of DOE O 435.1. Specifically, this requires that all NNSA/NV organizations, facilities, or activities that generate, treat, store, or dispose of radioactive waste develop a Radioactive Waste Information Document (RWID). RWIDs provide the backbone in support of a defensible basis as part of NNSA/NV's SWRWMP.

During the reporting period, extensive research was conducted by subject matter experts to determine the nature and quantity of wastes managed by NNSA/NV at the NTS and offsite locations within the state of Nevada and to identify the responsible parties subject to this order. This process also included the preliminary development of draft RWID documentation for future RWMBART review and approval. In support of the March 5, 2001, deadline, programmatic elements related to Team meetings and the RWIDs are planned for early 2001.

STATE OF NEVADA CHEMICAL CATASTROPHE PREVENTION ACT

The state of Nevada Chemical Catastrophe Prevention Act of 1992 contains regulations for facilities defined as Highly Hazardous Substance Regulated Facilities (NAC 1992). This law requires registration of facilities storing highly hazardous substances above listed thresholds. Reporting for this program is also covered by the Nevada Combined Agency Report discussed under EPCRA above.

A Chemical Catastrophe Accident Prevention registration form was submitted by NNSA for nitrogen dioxide, sulfur dioxide, thionyl chloride, anhydrous ammonia, and hydrochloric acid in July 2000.

There were no reportable EHS chemicals at other NNSA/NV facilities (NTS, RSL, NLVF) in 2000.

TOXIC SUBSTANCES CONTROL ACT (TSCA)

The state of Nevada regulations implementing the TSCA require submittal of an annual report describing polychlorinated biphenyl (PCB) control activities. The 1999 PCB Report indicated that there were no In-Service PCB Electrical Equipment (transformers/capacitors), and no Article Containers removed from service, and as of January 1, 2000, there were no known large PCB-containing tranformer/regulators remaining in service at the NTS that would require reclassification.

FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT (FIFRA)

Pesticide usage included insecticides, herbicides, and rodenticides. Insecticides were applied twice a month at the food service and storage areas. Herbicides were applied once or twice a year at NTS sewage lagoon berms. All other pesticide applications were on an as-requested basis. General-use pesticides are used exclusively at the NTS. Contract companies applied pesticides at all non-NTS facilities in 2000.

THREATENED AND ENDANGERED SPECIES PROTECTION

The ESA (CFR 1973) requires federal agencies to insure that their actions do not jeopardize the continued existence of federally listed endangered or threatened species or their critical habitat. The desert tortoise (*Gopherus agassizii*) and bald eagle (*Haliaeetus leucocephalus*) are the only threatened species which occur on the NTS. No endangered animals and no threatened or endangered plants are known to occur on the NTS. Consultation with the United States Fish and Wildlife Service (USFWS) resulted in receipt of a non-jeopardy Biological Opinion in August 1996 for planned activities at the NTS for a ten-year period (USFWS 1996).

The Desert Tortoise Compliance Program implemented the terms and conditions of the USFWS Biological Opinion and documented compliance actions taken by NNSA/NV. The terms and conditions, which were implemented in 2000, included (1) tortoise clearance surveys for 16 projects, (2) onsite monitoring of construction for 14 projects when heavy equipment was being used, (3) periodic monitoring of tortoise-proof fencing around the ER-5-2 Well and at sewage treatment ponds in Areas 6 and 23, and (4) preparation of an annual compliance report for the USFWS of NTS activities that were conducted in CY 2000. Project activities conducted in CY 2000 resulted in the loss of 6.21 acres of undisturbed tortoise habitat. Since issuance of the first non-jeopardy Biological Opinion in 1992, no tortoises have been accidentally injured or killed; no tortoises have been captured and displaced from project sites; and a total of 176.63 acres of desert tortoise habitat has been disturbed as a result of NTS activities.

In October 2000, a team of volunteer biologists, led by the Southern Nevada Field Office of the USFWS, captured, measured, and weighed desert tortoises within three 21-acre circular enclosures in Rock Valley. The circular enclosures were constructed during 1962-1963 to study the effects of chronic, low-level ionizing radiation on the desert flora and fauna. Over the past decades, at least 24 tortoises have been found, individually marked, and periodically measured. There are approximately 18 adult tortoises remaining in the enclosures. They are considered captive by the USFWS and are not protected under the 1996 Biological Opinion. In 2000, one immature tortoise and 17 adult tortoises were captured, measured, and weighed.

The threatened bald eagle is an uncommon transient to the NTS and is not expected to be impacted by NTS activities. No sitewide surveys to determine its distribution or abundance have been conducted. Records of all bird sightings, which are made opportunistically, are maintained to provide some data on the occurrence of various birds on the NTS. There were no reported sightings of bald eagles on the NTS in 2000.

HISTORIC PRESERVATION

The National Historic Preservation Act (NHPA) of 1966, the Archeological Resources Protection Act of 1979, and the regulations related to these laws direct federal agencies to inventory and manage the cultural resources under their stewardship. As of the end of 2000, approximately 8 percent of the NTS had been surveyed for cultural resources with more than 2,800 sites recorded. The NHPA also requires consultation with interested parties, especially Native Americans, in regard to historic preservation activities and proposed decisions affecting cultural resources.

NNSA/NV conducted cultural resources surveys and historical evaluations prior to undertakings in order to determine if proposed activities would adversely affect significant historic properties. Under the NHPA, all NNSA/NV cultural resources reports and plans are reviewed by the Nevada State Historic Preservation Office (NSHPO) for compliance with the NHPA. All consultations with the NSHPO were completed successfully, with proposed projects proceeding and documents finalized for distribution to the Nevada State Cultural Resources Archives.

Besides the obligation to identify, protect, and preserve the cultural resources eligible or potentially eligible for inclusion on the National Register of Historic Places, under the NHPA, NNSA/NV is required to maintain the archaeological materials recovered from the NTS in a secure and environmentally-controlled facility. NNSA/NV continued to maintain such a curatorial facility that houses more than a half million artifacts and associated records.

The American Indian Religious Freedom Act of 1978 affirms Native Americans right to religious freedom and defines the responsibility of federal agencies to consult with Native Americans in developing policies and procedures to protect and preserve cultural and spiritual traditions and sites. Executive Order 13007 of 1996 obligates federal agencies to accommodate the access to

- a MOU with Nevada covering releases of radioactivity.

- a MOU with Nellis Air Force Base for environmental restoration on the TTR.

- a FFACO with the state of Nevada on environmental restoration activities.

- a Consent Order under the FFCA with the state of Nevada regarding the storage of restricted mixed waste streams on the NTS.

- an Agreement in Principle (AIP) with Nevada on environment, safety, and health oversight activities.

- an AIP with Mississippi on environment, safety, and health oversight activities.

- an AIP with Alaska on environment, safety, and health oversight activities.

- a Settlement Agreement with Nevada concerning the of existing inventory of mixed TRU waste.

- a Mutual Consent Agreement with Nevada on storage and management of newly generated mixed LDR wastes on NTS.

3.3 CURRENT ENVIRONMENTAL COMPLIANCE ISSUES AND ACTIONS

There were numerous activities and actions relating to environmental compliance issues in 2000. These activities and actions are discussed below, grouped by general area of applicability.

CLEAN AIR ACT (CAA)

Under Title V, Part 70 of the CAA amendments, all owners or operators of Part 70 sources must pay annual fees to the state that are sufficient to cover the costs of operating permit programs.

Sources such as the NTS that have a potential to emit 50 tons or more of any regulated pollutant, except carbon monoxide, must pay an annual fee of $3,000. Sources that have a potential to emit less than 25 tons per year, such as the TaDD and UGTA projects, must pay an annual fee of $250. Maintenance and emissions fees of approximately $3,800 were paid to the NDEP in June 2000.

A modification package for the NTS Class II Air Quality Operating Permit AP9711-0549 was submitted to the state in November 1999 and the revised permit was issued on January 3, 2000. The main purpose of the modification was to add smaller “insignificant” fuel-burning sources to the permit with an annual limit on the number of hours the sources could operate. Fuel burning sources include generators, compressors, boilers, and miscellaneous equipment such as pumps. The modification was necessary due to the “potential to emit” nitrogen oxide, one of the criteria pollutants, approaching the 100-ton limit that is the cut off between being designated a minor (Class II) or a major (Class I) source. The potential to emit nitrogen oxides on the NTS is approximately 85 tons. On July 11, 2000, NNSA/NV and BN met with NDEP Bureau of Air Quality personnel in Carson City, Nevada, to discuss compliance with new, more stringent record keeping requirements that went into effect with issuance of the modified air permit.

During 2000, several open burn permits, know as Open Burn Variances, were issued by the state for NTS activities. These permits included 00-24 for training fires, 00-26 for emergency management drills, 00-93 for weapons of mass destruction training exercises, and 00-10 for the Area 27 burn box.

The NTS has a Nevada Hazardous Materials Storage Permit 13-00-0034-X, and the HSC has Permit 13-00-0037-X. These are issued by the state Fire Marshall and are renewed annually when a facility makes a report required by the state's Chemical Catastrophe Prevention Act (NAC 1992).

Table 3.6 contains a summary of the permits issued for NTS activities and for offsite activities that support the NTS.

Non-NTS Air Quality Permits

Five air quality operating permits were active for emission units at the NLVF, and seven permits were active for the RSL. These permits were issued through the Clark County Health District. Annual renewal is contingent upon payment of permit fees. Permits are amended and revised only if the situation under which the permit has been issued changes. For the other non-NTS operations, no air quality permits have been required, or the facilities have been exempted.

During 1998 the Air Pollution Control Division (APCD) of the Clark County Health District began requiring an "Emissions Inventory" submittal for all permitted sources. The 1999 Emissions Inventory was submitted by BN to the APCD on September 6, 2000.

CLEAN WATER ACT (CWA)

Low flows in several NTS sewage lagoons has reduced the efficiency of the lagoons to properly treat effluents. In response, the NNSA/NV has requested funding to install septic tank systems in these areas. The existing Permits for this program are shown in Table 3.5.

Permits issued by the state of Nevada, Division of Health for four sewage hauling trucks for the NTS were renewed in November 2000 and are listed in Table 3.5.

SAFE DRINKING WATER ACT (SDWA)

The NNSA/NV resolved the one remaining finding from a 1999 sanitary survey, a pinhole leak in a storage tank. The leak was successfully repaired in 2000. SDWA Permits are shown in Table 3.4.

The cross-connection control program at the NTS is not well documented, and NNSA/NV was not able to complete a Cross-Connection Control Plan, as required by state regulation. An engineering study has been commissioned and steps have been taken to correct the record-keeping deficiencies.

COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA)

Other than the reporting covered in Section 3.1, there is no formal CERCLA program at the NTS. The FFACO, with the state, may preclude the NTS from being placed on the National Priority List. More of a RCRA approach in remediating environmental problems will be taken under the FFACO.

POLLUTION PREVENTION (P2) AND WASTE MINIMIZATION

The CY 2000 P2, waste minimization, and recycling efforts for waste generated at the NTS, NLVF, and offsite locations complied with DOE Order 5400.1 requirements for a P2 program. The NNSA/NV P2 program establishes a process to reduce the volume and toxicity of hazardous waste generated at all locations and ensures that the proposed method of treatment and/or disposal minimizes the present and future threat to human health and the environment. It is a priority of NNSA/NV to minimize the generation, release, and/or disposal of pollutants to the environment by implementing cost-effective P2 technologies, practices, and policies in partnership with government and industry. A commitment to P2, waste minimization, and recycling manages operations in such a way as to minimize impact on the environment, improve the safety of operations and energy efficiency, and promote the sustainable use of natural resources. This commitment includes providing adequate administrative and financial materials on a continuing basis to ensure source reduction, recycling, and affirmative procurement goals are achieved.

Chapter 4.0 provides a summary of the P2 program, P2 accomplishments achieved during CY 2000, notable activities that achieved reduction in volume and toxicity of waste, and recycling activities and quantities.

SOLID/SANITARY WASTE

During CY 2000, landfills were operated in Areas 6, 9, and 23. The amount of waste disposed of in each is shown in Table 3.7, and their operating permits are in Table 3.6. Permits for the Area 9, U10c landfill and the Area 6 Hydrocarbon landfill were modified to allow accepting waste with a higher radiation level (consistent with local backgroud levels). This permit modification will reduce the amount of waste from various NTS cleanup/remediation projects which could require low-level waste disposal. The new limits allow for volumetric screening of wastes. Surface radioactivity of the waste is also measured.

The Biannual Solid Waste Disposal Report submitted to NDEP in July 2000 indicated that waste disposed of in the Area 23 Landfill exceeded permit limits (20 tons/day). Investigation revealed a database calculation error. A corrected report was resubmitted in September 2000.

RADIATION PROTECTION

NTS Operations

Results of monitoring during 2000 indicated full compliance with the radiation exposure guidelines of DOE Order 5400.5, "Radiation Protection of the Public and the Environment", and the Title 40 CFR 141 National Primary Drinking Water Regulations. Onsite air monitoring results for the networks showed average annual concentrations ranging from 0.5 percent of the DOE Order 5400.5 guidelines for HTO in air to 2.5 percent of the guidelines for $^{239+240}$Pu in air. Drinking water supplies on the NTS contained no man-made radioactivity above detection limits, and levels of naturally occurring radioactivity were in compliance with the National Primary Drinking Water Regulation.

Offsite monitoring in the vicinity of the NTS confirmed that emissions of radioactivity from the NTS did not exceed 2 percent of the guideline set forth in Title 40 CFR 61, Subpart H (CFR 1989).

Non-NTS BN Operations

Results of environmental monitoring at the off-NTS operations performing radiological work during 2000 indicate full compliance with the radiation exposure guidelines of DOE Order 5400.5. With one exception, no radioactive or nonradioactive surface water/liquid discharges, subsurface discharges through leaching, leaking, or seepage into the soil column, well disposal, or burial occurred at any of the BN operations. The exception was the NLVF Building A-1 radiation source well in which water was found with concentrations of tritium that were above the drinking water standard of 20,000 pCi/L. From a review of geologic reports, historical aerial photos, Geoprobe borings, installation of temporary monitoring wells, and water analyses, the tritium was concluded to be from past local operations and was not found in ground water surrounding the facility.

Use of radioactive materials is primarily limited to sealed sources. Facilities, which use radioactive sources or radiation producing equipment, with the potential to expose the general population or non-project personnel to direct radiation, are the Atlas NLVF A-1 Source Range, Building C-3 (x-ray radiography operation), and the STL, during the operation of the sealed tube neutron generator or during operation of the Febetron. Sealed sources are tested every six months to ensure there is no leakage of radioactive material. Operation of any radiation generating devices is controlled by BN procedures. At least two thermoluminescent dosimeters (TLDs) are placed at the fence line of these facilities or where non-project personnel could be for limited periods and are exchanged quarterly. The TLD results were consistent with previous data indicating no exposures to the public from any of the monitored facilities.

ENVIRONMENTAL COMPLIANCE AUDITS

There were nine Environmental Compliance Management Assessments of specific operations, facilities, or project for CY 2000. These assessments focused, in most cases, on one or two major areas of Environmental Compliance, e.g. hazardous waste or universal waste management.

OCCURRENCE REPORTING

Occurrences are environmental, health, and/or safety-related incidents, which are reported in several categories in accordance with the requirements of DOE Order O 232.1A, "Occurrence Reporting and Processing of Operations Information," (DOE 1997a). The eight reportable environmental occurrences for 2000 on NTS facilities appear in Table 3.8.

LEGAL ACTIONS

No legal actions were filed against NNSA/NV during 2000.

3.4 PERMITS FOR NTS OPERATIONS

Federal and state permits have been issued to NNSA/NV and to BN (Table 3.6). These permits are required for the conduct of such NNSA/NV activities as hazardous and solid waste storage and disposal for certain ecological studies, tests at the HSC, and for operations involving endangered species. All BN non-NTS facilities are located in existing metropolitan areas and are not subject to the Endangered Species Act. Annual reports associated with these permits are filed as stipulated in each permit.

The only RCRA permit in use at the NTS is the Hazardous Waste Management Permit NEV HW009. With this permit, hazardous waste generated at the NTS can be stored at the Area 5 HWSU for up to one year. It is then shipped offsite for treatment and/or disposal. The permit also allows for the thermal treatment (disposal) of explosives at the Area 11 Explosive Ordnance Disposal Unit.

The NLVF has a Waste Generator number of 03990265X that covers generation and a 90-day accumulation of hazardous waste. The waste is shipped offsite for final treatment and/or disposal.

NNSA/NV activities on the NTS comply with all terms and conditions of a desert tortoise incidental take authorization issued in a Biological Opinion (File Number 1-5-96-F-33) from the USFWS.

The Nevada Division of Wildlife issued a scientific collection permit, S20571 to BN that allows collection of wildlife samples.

Table 3.1 Active Air Quality Permits - 2000

Permit	Description	Expiration Date	Annual Reporting
NTS Air Quality Permits			
AP9711-0549		02/07/2002	February 1
Area 1 Facilities	Shaker Plant Circuit		
	Rotary Dryer Circuit		
	Wet Aggregate Plant		
	Concrete Batch Plant		
	Sandbag Facility		
	Cedar Rapids Screen		
	Shotcrete Hopper/Conveyor		
	Cambilt Conveyor		
	Commander Crusher		
	Kolberg Screen Plant		
Area 3 Facilities	Mud Plant		
Area 5 Facilities	Navy Thermal Treatment Unit		
Area 6 Facilities	Cementing Equip. (Silos)		
	Decontamination Facility Boiler		
	Diesel Fuel Tank		
	Gasoline Fuel Tank		
	Portable Field Bins		
	Portable Stemming Systems 1 & 2		
	Diesel Engines (11)		
	Two-Part Epoxy Batch Plant		
Area 12 Facilities	Concrete Batch Plant		
Area 23 Facilities	Building 753 Boiler		
	Diesel Fuel Tank		
	Gasoline Fuel Tank		
	NTS Surface Disturbances		
	Incinerator (Wackenhut)		
AP9711-0556	Area 5 HSC	10/20/2002	February 1
AP9711-0814	Area 11 TaDD Facility	07/21/2003	February 1
AP9711-0785	UGTA Surface Disturbance Permit	03/20/2003	February 1
00-24	Burn Variance, NTS (Training Fires)	03/09/2001	None
00-26	Burn Variance, NTS (EM Drill)	03/21/2001	None
Non-BN Operated NTS Air Quality Permits			
00-10	Burn Variance Area 27 (LLNL)	02/05/2001	None
BN Operated Off-NTS Air Quality Permits (TTR and NAFR)			
AP9711-0785	UGTA Class II Air Quality Permit	04/16/04	February 1

Table 3.2 Active Air Quality Permits for Non-NTS Facilities - 2000

Permit	Description	Expiration Date	Annual Reporting
	Remote Sensing Laboratory		
A0034811	Excimer Laser, Lumonics, EX-700	None	June 1
A34801	Boiler, Columbia, W1-180	None	March 1
A34802	Boiler, Columbia, WL-90	None	March 1
A34803	Heater, No. 2 Natl. BD	None	March 1
A34804(a)	Emergency Fire Control Pump Engine	None	June 1
A34804(b)	Emergency Generator, Cummins	None	June 1
A34805	Spray Paint Booth	None	June 1
	North Las Vegas Facility		
A38701	Spray Paint Booth (A-16)	None	June 1
A38703	Emergency Generators (C-1)	None	June 1
A06503	Emergency Generator (A-1/A-5/B-2)	None	June 1
A06505	Aluminum Sander (A-16)	None	June 1
A06507	Trinco Dry Blaster (A-1)	None	June 1

Table 3.3 Sewage Discharge Permits - 2000

Permit No./Location	Areas	Expiration Date	Reporting Required
	NTS Permits		
GNEV93001	NTS General Permit	12/07/2004	Quarterly
NY-17-05704	X Tunnel Collection System	09/30/2001	Quarterly
	Off-NTS Permits		
North Las Vegas Facility			
VEH-112	Class II Wastewater Contribution Permit	12/31/2001	Annually
Special Technologies Laboratory			
AII-204/Santa Barbara, California		12/31/2001	
III-331/Santa Barbara, California		12/31/2001	

Table 3.4 NTS Drinking Water System Permits - 2000

Permit No.	Area(s)	Expiration Date	Reporting Required
NY-5024-12CNT	Area 1	09/30/2001	None
NY-4099-12C	Area 2 & 12	09/30/2001	None
NY-360-12C	Area 5, 6, 22, 23	09/30/2001	None
NY-4098-12CNT	Area 25	09/30/2001	None
NY-835-12H	Sitewide Truck	09/30/2001	None
NY-836-12H	Sitewide Truck	09/30/2001	None
NY-841-12H	Sitewide Truck	09/30/2001	None

Table 3.5 Permits for NTS Septic Waste Hauling Trucks - 2000

Permit Number	Vehicle Identification Number	Expiration Date
NY-17-03313	Septic Tank Pumper E-105293	11/30/2001
NY-17-03315	Septic Tank Pumper E-105919	11/30/2001
NY-17-03317	Septic Tank Pumper E-105918	11/30/2001
NY-17-03318	Septic Tank Pumping Subcontractor	11/30/2001
NY-1076	Septic System Area 6 (Art Hangar)	None
NY-1077	Septic System, Area 27	None
NY-1078	Septic System, Area 5 (Bldg 5-8)	None
NY-1079	Septic System, Area 12 (U12g Tunnel)	None

Table 3.6 Permits Required for NTS Operations - 2000

EPA Generator ID		
NV3890090001	NTS Activities	
NTS Permits		
Permit No.	**Areas**	**Expiration Date**
NEV HW009	NTS Hazardous Waste Management (RCRA)	05/01/2000
SW 13 097 02	Area 6 Hydrocarbon Disposal Site	Post Closure
SW 13 097 03	Area 9 U-10c Solid Waste Disposal Site	Post Closure
SW 13 097 04	Area 23 Solid Waste Disposal Site	Post Closure
13-00-0034-X	NTS Hazardous Materials	02/29/2000
13-00-0037-X	HSC Hazardous Materials	02/29/2000
S20571	Scientific Collection of Wildlife Samples	12/31/2000
MB0037277-0	USFWS -- Desert Tortoise Incidental Take Authorization	12/31/2000
Off-NTS Permits		
03-00-0265-X	North Las Vegas Facility Hazardous Materials	02/29/2000
03-00-0266-X	Remote Sensing Laboratory Hazardous Materials	02/29/2000
EPA Generator ID Numbers		
NVD097868731	North Las Vegas Facility Activities, NV	
CAL00177640	Santa Barbara Operations, CA	
CAL00177642	Santa Barbara Operations, CA	
CAL00197065	Livermore Operations, CA	
NMD986670370	Los Alamos Operations, NM	

Table 3.7 Quantity of Wastes Disposed of in Solid Landfills - 2000

	Quantity (in tons)		
Month	**Area 9**	**Area 23**	**Area 6**
January - March	1,136	547	132
April - June	908	440	35
July - September	2,295	822	1,312
October - December	2,115	288	636
Totals	**6,454**	**2,097**	**2,115**

Table 3.8 Off-Normal Occurrences at NTS Facilities - 2000

Date	Report Number	Description	Status
01/11/2000	NVOO-BNLV-NTS 2000-0001	Approximately 10 gallons of hydraulic oil leaked from an earth grader at the Area 23 landfill.	Open
03/09/2000	NVOO-BNLV-NTS 2000-0006	A screening survey at Area 25 EMAD found unexpected elevated radiation readings in an uncontrolled area.	Closed
03/14/2000	NVOO-BNLV-NTS 2000-0007	A screening survey at Area 25 EMAD found unexpected elevated radiation readings in an uncontrolled area.	Closed
05/11/2000	NVOO-BNLV-NTS 2000-0012	A screening survey at Area 25 EMAD found unexpected elevated radiation readings in an uncontrolled area.	Closed
08/02/2000	NVOO-BNLV-NTS 2000-0016	Failure to submit Exception Report for non-return of hazardous waste manifest.	Open
08/02/2000	NVOO-BNLV-NTS 2000-0017	Heating oil spill while filling tank at Area 23, Building 536, resulted in state notification.	Open
09/14/2000	NVOO-BNLV-NTS 2000-0022	Historic heating oil spill at Area 23, Building 156.	Closed
10/25/2000	NVOO-BNLV-NTS 2000-0027	Non PCB transformer oil leak at Area 2, Building 2C-20.	Open

4.0 ENVIRONMENTAL PROGRAM INFORMATION

Reported in this section are the environmental stewardship programs for the Nevada Test Site (NTS). These programs are under the purview of the Environment, Safety and Health Division (ESHD) of the U.S Department of Energy (DOE), National Nuclear Security Administration Nevada Operations Office (NNSA/NV) for environmental management and compliance, field investigations for impact assessment, ecosystem management, pollution prevention (P2), waste minimization, science, and technology development.

4.1 ROUTINE RADIOLOGICAL ENVIRONMENTAL MONITORING PLAN

The NNSA/NV manages the NTS in a manner that meets evolving NNSA missions and responds to the concerns of affected and interested individuals and agencies. The Routine Radiological Environmental Monitoring Plan (RREMP) addresses compliance with DOE Orders and other drivers requiring routine effluent monitoring and environmental surveillance on the NTS. The RREMP describes the objectives and design elements for all media: air, water, soil, biota, and direct radiation sources. Existing and historical site information and regulatory requirements were reviewed and site characteristics, transport and exposure pathways, regulatory requirements, and historical data evaluated to support the monitoring designs. Both onsite and offsite monitoring objectives are addressed under the RREMP.

The RREMP identifies the requirements for radiological monitoring on and off the NTS and focuses on the need to ensure that the public and the environment are protected, that compliance with the letter and the spirit of the law is achieved, and that good land stewardship is practiced. The monitoring plan uses a decision-based approach to identify the environmental data that are collected and provides Quality Assurance, Analysis, and Sampling Plans, which ensure that defensible data are generated.

AIR MONITORING

Environmental monitoring includes the activities of environmental surveillance, effluent monitoring, and operational monitoring. For air monitoring, the principal difference among these three activities is the placement of the air sampling equipment. Environmental surveillance targets ambient air, but not specific facilities; while effluent and operational monitoring target facilities or activities. Effluent monitoring is directed at the measurement of a specific emission point, while operational monitoring is used to assess total emissions from an operating facility. The rationale, supporting the design of the air monitoring network for the NTS, addresses these types of monitoring and is discussed thoroughly in the RREMP.

The objective for the air monitoring network is to monitor all NTS radionuclide emissions above some reasonable lower limit, such that no significant emission source that contributes to calculable offsite exposures is ignored and to ensure that the NTS is in full compliance with the requirements of the Clean Air Act. The regulatory driver for this network includes Title 40 Code of Federal Regulations (CFR) 61, “National Emission Standards for Hazardous Air Pollutants (NESHAPs): Radionuclides,” Subpart H – “National Emission Standards for Emission of Radionuclides Other Than Radon From Department of Energy Facilities.” Other drivers include DOE Order 5400.1 – “General Environmental Protection Program,” DOE Order 5400.5 – “Radiation Protection of the Public and the Environment,” and DOE/EH-0173T – “Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance.” These documents prescribe dose limits and air monitoring requirements.

To comply with the regulations listed above, a combination of approaches is used:

- Evaluating operational contributions through measurement of particulate-in-air and tritium-in-air emissions from such sources as the Radioactive Waste Management Sites (RWMSs) in Areas 3 and 5, and the Waste Examination Facility.

- Monitoring air at locations on the NTS known to be contaminated with radionuclides in order to evaluate the behavior of radionuclide emissions from those locations.

- Calculation of tritium in air based on the amounts of tritium in surface waters, confirmed through the observed behavior of tritium in air near tritium sources.

- Modeling particulate emissions in air using a soil resuspension model, based on the observed behavior of particulate emissions in air and confirmed by particulate air monitoring data in selected offsite locations.

- Calculating an effective dose equivalent for each specific emission source at the NTS, using the CAP88-PC model as prescribed by NESHAPs, to provide dose calculations for all populated locations within 80 km (50 mi) (the location of the general public is assessed annually).

During the year 2000, no point sources qualified for offsite monitoring under NESHAPs requirements (capable of emitting $\geq$1 percent of the standard); however, point sources are continually evaluated for this potential. Accidental releases from facilities such as U-1a, Area 27, or the Device Assembly Facility will be monitored through the ambient monitoring network.

SURFACE WATER

The objectives of the routine radiological monitoring program for surface water are to determine (1) if concentrations of radionuclides in surface water bodies at the NTS and its vicinity are a threat to public health and the environment, and (2) if permitted facilities are in compliance with permit discharge limits.

The surface water sample locations on the NTS include the E Tunnel containment ponds and nine sewage lagoons; offsite locations include nine natural springs. The criteria for selection were based on the monitoring objectives. Water sources have been selected based on potential for exposing the public, onsite biota, or the environment to significant levels of radionuclides, or requirements for monitoring under existing state discharge permits. The sources are as follows:

- Discharge from E Tunnel is collected in containment ponds and monitored under the current state permit.

- The nine sewage lagoons at the NTS receive effluents from sewage treatment plants permitted by the state (Bechtel Nevada [BN] 1997). Radionuclide monitoring of these lagoons is required under the current state permit.

- Several offsite springs have been historically monitored and will continue to be monitored under this program. Six of the historically monitored springs are included in this plan; three springs not previously monitored will be added to the program; one for semiannual and two for annual sampling. These springs are discharge sites for the local and regional aquifers, for which the upgradient direction may be the underground testing area on Pahute Mesa. The offsite springs chosen for the monitoring network are therefore used as groundwater monitoring points in this hydrologic system. Continued monitoring will document and track trends in groundwater quality downgradient of the underground nuclear test sites on the NTS. Radionuclide levels at all these surface water sources mentioned above have consistently been below the Derived Concentration Guides listed in DOE Order 5400.5 over recent years (DOE 1990b).

GROUNDWATER

The characteristics of regional and local groundwater regimes at the NTS and the sources of radionuclides with potential impacts on groundwater are presented in Chapters 7.0 and 8.0 of this report. Groundwater is monitored onsite and offsite to comply with several regulatory drivers.

The objectives of the routine radiological monitoring program for groundwater include:

- **Water Supply Well Monitoring:** Determine if onsite water supply wells are impacted from radionuclides originating from NNSA operations on the NTS.

- **Permitted Facilities Monitoring:** Determine if there are groundwater impacts from surface and shallow vadose zone sources of radionuclides on the NTS.

- **Aquifer Monitoring:** Determine if groundwater at the NTS and its vicinity is further degraded as a result of the expansion of the radionuclide plumes associated with the underground test areas.

- **Water-level Information:** Determine the potential impact of demand for groundwater around the NTS on the long-term availability of water.

Water Supply Wells

Groundwater is the only local source of drinking water at the NTS and the surrounding area. The state permit for the NTS includes four drinking water supply systems that consist of ten potable water wells. These wells are sampled to determine compliance with the Safe Drinking Water Act (SDWA) and Nevada Revised Statutes (NRS), which include standards for radionuclides. In addition to the water supply wells onsite, the network will include offsite water supply and existing monitoring wells selected based on the following criteria:

- Select point-of-use water supply wells downgradient of the NTS (in the general direction of regional groundwater flow). Current site knowledge eliminates the possibility of transport of radionuclides from source areas to wells upgradient of the NTS, or opposite to the general direction of regional groundwater flow.

- Select wells close to the NTS boundary and in close proximity to the underground testing areas.

- Give preference to community wells.

- Give preference to high-yield, high-volume wells.
- Give preference to wells with appropriate construction/condition.
- Select wells where access is possible.
- Consult with Community Environmental Monitoring Programs to ensure that the concerns of local communities are addressed.

Permitted Facilities Wells

Five wells located at three facilities require routine groundwater monitoring under the terms of permits issued by the state of Nevada. These facilities are the Area 5 RWMS (RWMS-5), the Area 23 Infiltration Basin, and the Area 12 E Tunnel pond.

The Pit 3 Mixed Waste Disposal Unit located in the RWMS-5, currently under Resource Conservation and Recovery Act (RCRA) Interim Status, maintains compliance with Title 40 CFR 264/265 by monitoring three wells around the RWMS-5.

To comply with the groundwater protection requirements of the state General Permit GNEV93001, a monitoring well was installed (SM-23-1) in 1996 for the Area 23 Infiltration Basin.

Water Pollution Control Permit NEV96021, in compliance with the provisions of the Federal Water Pollution Control Act and NRS, allows NNSA/NV and the Defense Threat Reduction Agency to manage and operate a system for the treatment and disposal of waste water discharging from the portal of E Tunnel in Area 12 of the NTS. The effluent from the portal is conveyed into six earthen impoundments for disposal by means of infiltration.

Groundwater from the five permitted wells is sampled for the necessary constituents and at the required frequency as stated in the permit.

Aquifer Monitoring

The RREMP includes an interim effort to identify existing wells and boreholes (called point-of-opportunity wells), that are located downgradient of the Corrective Action Units (CAUs) and/or are in the regional aquifer. Point-of-opportunity wells located within CAUs have been screened based on the following criteria for their inclusion in the proposed network:

- Select point-of-opportunity wells downgradient of source areas.
- Give preference to wells within 1,000 m (3,280 ft) of underground tests, which are located below or within two cavity radii of the water table.
- Select wells accessing relevant hydrostratigraphic units within structural blocks having an upgradient source or sources.
- Give priority to wells in those transmissive units which also contain most of the underground test locations.

Wells screened have been further scrutinized to select those which would be most cost-effective to monitor, with the following construction criteria:

- Give priority to wells with immediate access to the aquifer.
- Give priority to wells with diameters already appropriate for sampling.
- Give priority to wells that are already completed (developed, casing exists, etc.).

Point-of-opportunity wells are existing wells which, according to the present level of understanding, appear to be at appropriate locations and completed in appropriate hydro-stratigraphic units. It is important to note that the groundwater monitoring in the RREMP is an interim program until the final CAU postclosure monitoring network can be designed and implemented.

Hot wells, also referred to as source-term characterization wells, are those used to sample groundwater from within or near the cavities produced by underground nuclear tests that were conducted below the water table. These groundwater samples are used to define the hydrologic source term (the type and concentration of radionuclides dissolved in groundwater, or potentially available to groundwater). Source term information fulfills the requirement in DOE Order 5400.1 to monitor the effects of NNSA/NV activities on the environment. This monitoring allows estimates to be made of the rate of radionuclide migration from the underground nuclear tests.

In addition to wells monitored for potential releases, water-level measurements will be performed for each sampling event at all wells if practical (e.g., no downhole pump in well). There are wells onsite and offsite that are monitored only for water levels by the U.S. Geological Survey (USGS). Data from these wells are analyzed for trends, impacts of water usage, and used to calibrate groundwater flow models.

VADOSE ZONE MONITORING (VZM)

The vadose zone is being monitored at three general types of sites on the NTS: RWMSs (Areas 3 and 5); RCRA closure sites (Area 23 Hazardous Waste Landfill and U-3fi); and permitted sanitary landfills (U-10c Landfill and the Area 6 Hydrocarbon Landfill) in addition to, or in lieu of, groundwater monitoring for the purpose of protecting groundwater resources. VZM at these sites generally consists of monitoring changes in soil moisture.

VZM offers many advantages over groundwater monitoring including detecting potential problems long before groundwater resources would be impacted, allowing corrective actions to be made early, and being less expensive than groundwater monitoring.

VZM at the RWMSs is driven by DOE Orders and conducted to confirm Performance Assessment (PA) assumptions regarding the hydrologic conceptual models including soil water contents, and upward and downward flux rates. VZM at RCRA closure sites and sanitary landfills is driven entirely by agreements with the Nevada Division of Environmental Protection (NDEP). Vadose zone monitoring at all NTS sites is also conducted to:

- Demonstrate negligible infiltration of precipitation into zones of buried waste
- Detect changing trends in performance
- Establish baseline levels for long term monitoring.

Compliance at the RWMSs is achieved by demonstrating that PA assumptions are valid, and that there is negligible infiltration of precipitation into zones of buried waste. Compliance at the RCRA sites and sanitary landfills is achieved by demonstrating that soil moisture levels remain within limits agreed to with NDEP.

At the RWMSs, VZM is conducted by measuring all the water balance components at several locations to account for some spatial variability, and to apply that water balance to an entire RWMS using a concept of surrogate sampling. This type of VZM is not leak detection, it is performance monitoring.

Water balance measurements activities include:

- Meteorological monitoring to measure precipitation (the driving force for downward flow), and to calculate potential evapotranspiration (the driving force for upward flow),

- Lysimeters (weighing and drainage) to measure infiltration, soil water redistribution, bare-soil evaporation, evapotranspiration, and deep drainage.

- Neutron logging through access tubes to measure infiltration, soil water redistribution, and to monitor a large spatial area (in some locations to depths of hundreds of feet).

- Automated vadose zone monitoring systems with *in situ* sensors (time domain reflectometry probes, and heat dissipation probes) to measure soil water content and soil water potential over a large spatial area, but usually to a limited depth.

- Soil-gas sampling for tritium to confirm PA assumptions and transport coefficients.

This strategy provides an accurate estimate of the RWMS water balance including any drainage through the RWMS waste covers, and therefore, potential recharge. Based on these data, as well as other work (Tyler et al., 1996), there is essentially no recharge to the groundwater under current conditions in the valleys of the NTS (including the RWMSs), and all precipitation is effectively returned to the atmosphere by plant transpiration and soil evaporation.

The VZM strategy for the two RCRA closure sites and permitted sanitary landfills is similar to the RWMS strategy and is based on monitoring soil moisture at points of opportunity. At these sites, neutron logging is conducted in boreholes that were originally drilled for site characterization purposes. Neutron logging at these sites provides data to confirm that there is negligible infiltration of precipitation into zones of buried waste.

A summary of some selected NTS VZM data can be found in Chapter 8.0.

BIOTA MONITORING

Historical radionuclide studies on the NTS focused on man-made transuranics and showed declining concentrations in plants and animals over time (DOE 1992), although some plant and animal samples still contain measurable levels (EG&G/EM 1993; U.S. Environmental Protection Agency [EPA] 1996). These past studies indicate that significant radionuclide damage to plants and animals on the NTS would occur only during atmospheric nuclear testing. Given the current NNSA/NV project and land use policy, it is unlikely that NTS radionuclide contamination poses a significant threat to biota, although data to confirm this conclusion have yet to be taken. Past studies, although limited in scope and area, indicate that radionuclides in NTS plants and animals posed no significant threat of radiation exposure to the offsite public. Current NTS land use precludes the harvest of plants or plant parts (e.g., pine nuts, wolf berries) for direct consumption by humans. Therefore, the primary potential exposure pathway of radionuclides in NTS plants to the public is through ingestion of game animals. Game animals (e.g., mourning doves, chukar, rabbits as surrogates for Deer) may eat contaminated plants, seeds, or soil or they may drink contaminated water on the NTS and then travel offsite where they are subsequently hunted by the public for food. The expected public dosage via these pathways from NTS biota are well below established dose limits.

Offsite plants and animals, namely crops and livestock in neighboring communities, have also been monitored for years to document possible radionuclide exposure to the public (EPA 1978; EPA 1996). The only possible current pathway for radiation exposure through crops is their uptake of radionuclides from soil which was contaminated during past atmospheric tests. There are several communities to the north and east of the NTS (e.g., Rachel, Alamo, Hiko) that have received radioactive fallout in the past from these tests. Recent radioanalysis of selected fruits and vegetables from these communities has shown levels of tritium, strontium, and plutonium near or below detection limits (EPA 1996). Livestock or game animals within the same downwind fallout areas could ingest contaminated forage and then be consumed by humans. Strontium levels in the bones of deer, cattle, and bighorn sheep sampled in 1993 off the NTS were above detection limits, but have consistently decreased in samples since the early 1960s since cessation of aboveground testing (EPA 1996). The edible portions of these offsite animals historically contain nondetectable levels of radionuclides. However, strontium levels in milk from pasture-fed cows sampled from neighboring Nevada ranches have been periodically measured at levels above detection limits (EPA 1996).

Given the assumption that there exists no significant risk to plants, animals, or the public through the food chain from radionuclide contamination, it is still expedient to include biota samples within the framework of this monitoring at the NTS for the following reasons:

- Some level of biota monitoring is needed to comply with DOE Order 5400.1.
- Biota monitoring data are needed to validate the integrity of land buffers.
- Biota data will be needed to address current and future land-use issues.

The NTS Biota monitoring effort is designed for radiological monitoring of NTS plants and animals and focused on sampling those sites having the highest known concentrations of radionuclides in other media. The intent is to concentrate monitoring efforts at sites where the likelihood for radionuclides to enter plants and game animals is the highest on the NTS, including:

- Runoff areas or containment ponds associated with underground or tunnel test areas.
- Plowshare sites.
- Atmospheric test areas.
- Atmospheric safety experiment sites.

A control site for each contaminated site will be selected and will have similar biological and physical features, but will have no history of radionuclide contamination from NNSA/NV activities above worldwide levels of fallout. Measurements from the control sites will be used to document radionuclide levels in biota from areas believed to be uncontaminated by past and ongoing NNSA/NV activities and representative of background levels.

NTS Chukar Sampling Sites

In the past, the Nevada Division of Wildlife (NDOW) has requested, and has been granted, permission to trap and remove chukar from the NTS. The chukar are then released in areas open to public hunting. Chukar are trapped by the NDOW at one to three of the numerous natural springs on the NTS. Chukar trapped at these springs are not expected to be contaminated, but they will be sampled from these springs for radiological analysis on a routine basis. In 2000, attempts were made to trap Chukar, but were unsuccessful.

DIRECT RADIATION MONITORING

Direct radiation monitoring is used to detect radiation exposures caused by sources that emit X rays, gamma rays, charged particles, and/or neutrons. Such monitoring can be done in real time by use of appropriate survey meters or by pressurized ion chambers (PICs) to obtain exposure rate and by various types of solid-state dosimeters to obtain total exposure.

The objective of onsite Thermoluminescent Dosimeter (TLD) and PIC monitoring is to assess the state of the NTS's external radiation environment, detect changes in that environment, and measure gamma radiation levels near and in contaminated areas on the NTS. The onsite monitoring program will be used for trend analysis, in conjunction with fly-over data and demarcation studies, and to comply with DOE Orders. The data from environmental TLDs may also be used during future facility siting decisions.

4.2 POLLUTION PREVENTION AND WASTE MINIMIZATION PROGRAM

When economically feasible, source reduction is the preferred method of handling waste, followed by reuse and recycling, treatment, and, as a last resort, land disposal. The NNSA systematic approach to source reduction is achieved by performing pollution prevention opportunity assessments (PPOAs). The objective of a PPOA is to identify methods to reduce energy consumption and/or eliminate waste streams via a planned and documented procedural process. Subsequently, the technical and economical feasibility of options are evaluated, and the most feasible option is selected for implementation. Options include product substitution, process change (i.e., use of alternate equipment or procedure), and onsite and offsite recycling. When selecting which PPOA to perform, the goal is to reduce or eliminate the volume and/or toxicity of waste.

Another effective method for source reduction is the coordination of the material exchange program within NNSA/NV and between NNSA/NV and other agencies (e.g., EPA). Unwanted chemicals, supplies, and equipment are posted on the intranet material exchange list so that individuals in need can obtain the items at no cost. These materials are destined for disposal, either as solid or hazardous waste, as a result of process modification, discontinued use, or shelf life expiration. Rather than disposing of these items, the majority of them are provided to other employees for their intended purpose, thus avoiding disposal costs and costs for new purchases. If items are not placed with another user, they can be returned to the vendor to be recycled or reused.

EMPLOYEE AND PUBLIC AWARENESS

As stated in DOE Order 5400.1, chapter III-4c, NNSA/NV's P2 program must include the implementation of an employee awareness program. Employee awareness of P2 issues throughout NNSA/NV is accomplished by dissemination of articles through both electronic mail and NNSA/NV newsletters, the development and maintenance of a P2 intranet website, employee training courses, and participation at employee and community events. These activities are intended to increase awareness of P2 and environmental issues and their role in improving environmental conditions in the workplace and community.

POLLUTION PREVENTION ACTIVITIES

The NNSA/NV demonstrated efforts to deactivate reactive waste, specifically the treatment of waste explosives at the NTS Area 11 Explosive Ordnance Disposal Unit (EODU). Approximately 16.8 kg (37.1 lb) of reactive hazardous waste (waste explosives) were treated at the EODU during calendar year (CY) 2000.

One PPOA was implemented during CY 2000. A process was established to recycle all electronic media (floppy disks, compact disks, backup tapes, magnetic tapes, reel-to-reel tapes, video tapes, audio tapes, etc.). Unused and/or obsolete electronic media is sent to the

Information Systems Department electronic media repository. At the repository, it is sorted between unusable and usable. Usable electronic media is redeployed to personnel with a need for that media. Unusable media is packaged and sent to an offsite vendor. The media is degaussed to remove all information, disassembled, and the parts recycled. Approximately 2.56 metric tons (mt) of material and equipment was sent to an offsite vendor for recycle in CY 2000.

Through the material exchange program, approximately 0.81 mt of materials and equipment were exchanged. Both hazardous and non-hazardous materials were included.

The following activities enhanced employee awareness of P2 practices:

- Earth Day: The week-long event included an exhibit of office products containing post consumed recycled materials in accordance with Affirmative Procurement; handouts of literature on helpful P2 hints; articles published in the Sitelines publication; P2 messages through electronic mail; and distribution of promotional items made from recycled materials as daily reminders regarding the benefits of recycling.

- Holiday and all-occasion card collection: Holiday and all-occasion cards are collected and donated to St. Jude's Ranch for abused and neglected children. These cards are recycled into new cards. The new cards are then sold in the St. Jude's Ranch gift shop. Proceeds from the sale help support the children.

- Integrated Safety Management Day: The event included an exhibit of P2 success stories; literature containing P2 holiday tips; literature about composting; and distribution of promotional items made from recycled materials as daily reminders regarding the benefits of recycling.

- Family Day at the NTS: The event included an exhibit of the various P2 and Waste Minimization activities performed at the NTS; literature containing P2 tips; literature about composting; and distribution of promotional items made from recycled materials as daily reminders regarding the benefits of recycling.

- Publication of various P2 articles: Another means of employee communication includes dissemination of articles through both electronic mail and NNSA/NV newsletters with the intent of increasing employee awareness of environmental issues and their role in improving environmental conditions in the workplace and community.

- P2 Website: An intranet P2 website has been on-line since April 1998. Information found on the website includes, but is not limited to: points of contact, management commitment, P2 Program Plan, P2 success stories, employee suggestions, material exchange program, list of people interested in car pooling, and current P2 activities.

- Training: Management and employees are instructed in P2 and waste minimization policies and practices during classroom training courses (e.g., Hazardous Waste Site General Worker Operator and Emergency Response, Waste Management for the Generator, Rad Worker II, and General Employee Orientation).

VOLUME AND TOXICITY REDUCTION

Table 4.1 is an overview of the estimated RCRA hazardous waste and toxicity reduction through implementation of P2, waste minimization, material exchange, and recycling activities during CY 2000. These activities eliminated an estimated 102.3 mt of RCRA hazardous waste.

RECYCLING ACTIVITIES

Through recycling, hazardous and solid waste disposal can be significantly reduced or eliminated, reducing costs associated with disposal, shipping, and labor. Table 4.2 lists the recycling activities that occurred at NNSA/NV.

4.3 HAZARDOUS MATERIALS SPILL CENTER (HSC)

Biological monitoring at the HSC is required for certain types of chemicals under the Center's Environmental Assessment. These chemicals have either not been tested before, have not been tested in large quantities, or have uncertain modeling predictions of downwind air concentrations. In addition, the NNSA's ESHD has requested that BN monitor (downwind) any test which may impact plants or animals outside the experimental area.

A document entitled "Biological Monitoring Plan for Hazardous Materials Testing at the Liquefied Gaseous Fuels Spill Test Facility on the Nevada Test Site" (BN 1996) has been prepared that describes the conduct of field surveys used to determine test impacts on plants and animals and verify that the spill program complies with pertinent state and federal environmental protection legislation. The monitoring plan calls for the establishment of three control transects and three treatment transects, which have similar environmental and vegetational characteristics, at three distances from the chemical release point. BN biologists review spill test plans to determine if field monitoring along the treatment transects is required as per the monitoring plan criteria.

BN reviewed chemical spill test plans for one experiment: REOP-CHLOREP Special Equipment and Techniques Mercury Workshop. Biota monitoring was not conducted for any of the chemical tests at the HSC during 2000. No baseline monitoring was conducted at established control-treatment transects near the HSC due to insufficient funding.

4.4 RADIOACTIVE WASTE MANAGEMENT SITES

DISPOSAL ACTIVITIES

The Areas 3 and 5 RWMSs, at the NTS, are designed and operated for disposal of low-level waste (LLW) from onsite, NNSA offsite, and other offsite generators and mixed waste from onsite. All generators of waste streams must first request to dispose of waste, submit an application for specific waste streams, meet NTS Radioactive Waste Acceptance Criteria, and receive approval for disposal by NNSA/NV. Waste Acceptance criteria are based on how well the site is predicted to perform as described in Performance Assessment/Composite Analysis documents. Environmental Monitoring collects data to determine if performance is as expected and to meet regulatory compliance requirements. Disposal consists of placing waste in various sealed containers in the unlined pits and trenches. Soil backfill is pushed over the containers in a single lift, approximately 2.4 m (8 ft) thick, as rows of containers reach approximately 1.2 m (4 ft) below original grade.

Waste disposal at the RWMS-5 has occurred in a 37-hectare (92-acre) portion of the site, referred to as the LLW Management Unit (LLWMU), since the early 1960s. The LLWMU consists of 23 landfill cells (pits and trenches) and 13 Greater Confinement Disposal (GCD) boreholes. Four of the GCD boreholes were used to dispose of transuranic (TRU) waste and are no longer active; five contain LLW and are no longer active; and the remaining four have not been backfilled with soil. Of the 23 landfill cells, 5 are open for disposal of LLW, one is an active mixed waste disposal unit, and one is used for disposal of asbestos-form LLW. The remaining 15 landfill cells are covered and no longer active (14 contain low-level radioactive waste and 1 contains TRU waste). In CY 2000, the RWMS-5 received 312 shipments containing 346,664 cubic feet of LLW and 2 shipments containing 40 cubic feet of Mixed LLW (MLLW) for disposal.

Key documents in place that are necessary for disposal operations to occur are as follows:

- A Disposal Authorization Statement (DAS) was issued in December 2000 for RWMS-5.
- Performance Assessment for the RWMS-5 at the NTS, Nye County, Nevada, Revision 2.1, January 1998.
- Composite Analysis for the RWMS-5 at the NTS, Nye County, Nevada. February 2000.
- NTS Waste Acceptance Criteria (NTSWAC) Revision 3 - December 2000.
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4.5 HISTORIC PRESERVATION

In 2000, five cultural resource surveys, one inventory project and six historical evaluations were conducted at the NTS . The five surveys were undertaken to determine if significant sites or structures were located within proposed project areas, covering an area of 200 acres. No new sites were identified as a result of these surveys. The inventory project, meeting the requirements of the National Historic Preservation Act, Section 110, was conducted at Cane Spring as a continuation of investigations at spring sites on the NTS. This research indicates that initial occupation of the spring by Native Americans began as early as 10,000 B.C., with historic occupation of the site into the 1920s. The Cane Spring site has been determined to be eligible for the National Register of Historic Places (NRHP) and the technical report summarizing the work there was finalized in 2000. Five historical evaluations were conducted at facilities where buildings have been identified to be demolished under the NNSA/NV Environmental Management Deactivation and Decommissioning (D&D) Program. Three of the facilities were built for the ROVER program, an endeavor to develop nuclear rocket engines that began in the 1950s and ended in the 1970s. These are the Reactor Maintenance Assembly and Disassembly (RMAD) facility, Test Cell A Facility and Test Cell C Facility. The fourth was the Pluto Disassembly Building associated with development of nuclear propulsion for aircraft. The fifth survey was of the Super Kukla Facility where activities supported the weapons testing programs from 1964 to 1979. Historical evaluation reports were completed for all five facilities and they were determined eligible to the NRHP for their association with important events in our history. After consultations with the Nevada State Historic Preservation Office (NSHPO) and the National Park Service, a decision was made to conduct work to mitigate the adverse effects from the demolition of buildings at these facilities. Historic American Engineering Record documentation is in progress for the primary RMAD building, the test cells at Test Cell A and C, the Pluto Disassembly Building, and the primary building at the Super Kukla facility. The sixth historical evaluation focused on the nuclear testing remains from the APPLE - 2 atmospheric test. The survey identified 15 structures, buildings and features, establishing the APPLE - 2 historic district. This district has been determined eligible to the NRHP with the results presented in a technical report. Also, the technical report on the Frenchman Flat historic district was finalized in 2000. All determinations of eligibility were made through consultation between NNSA/NV and the NSHPO.

The field aspect of the program to monitor the historic properties on the NTS was initiated in 2000. The purpose of this program is to determine if NRHP eligible sites are being adversely affected by natural and human activities. Eleven sites were examined and all the sites retained their integrity.

Since 1990, the NNSA/NV has been involved in consultations with Native American tribal groups in Nevada, California, Arizona and Utah, who have historical ties to NTS land. The three major groups are the Western Shoshone, the Southern Paiute, and the Owens Valley Paiute. In 2000, a draft book manuscript was prepared that summarizes the decade of ethnographic research with these people.

4.6 UNDERGROUND TEST AREA PROJECT

The Underground Test Area (UGTA) Project is the largest project in the Environmental Restoration Division and addresses groundwater contamination resulting from past underground nuclear testing conducted in shafts and tunnels by the NNSA/NV on the NTS.

From 1951 to 1992, more than 800 underground nuclear tests were conducted at the NTS. Most of these tests were conducted hundreds of feet above the groundwater table; however, over 200 of the tests were in proximity of, or within, the water table. This underground testing was limited to specific areas of the NTS including Pahute Mesa, Rainier Mesa/Shoshone Mountain, Frenchman Flat, and Yucca Flat.

The UGTA Project collects data to define groundwater flow rates and direction to determine the nature and location of aquifers (geologic formation of permeable rock containing or conducting groundwater). In addition, project team members gather information regarding the hydrology and geology of the area under investigation. Data from these studies will determine whether or not radionuclides resulting from nuclear testing have moved appreciable distances from the original test location. Numerous surface and subsurface investigations are ongoing to assure that these issues are addressed.

Surface investigations include:

- Evaluating discharges from springs located downgradient of the NTS.
- Assessing surface geology.

Subsurface investigations include:

- Drilling deep wells to access groundwater hundreds to thousands of feet below the surface.
- Sampling groundwater to test for any radioactive contaminants.
- Assessing NTS hydrology and subsurface geology to determine possible groundwater flow direction.

A regional three-dimensional computer groundwater model (International technology [IT] 1996a) has already been developed to identify any immediate risk and to provide a basis for developing more detailed models of specific NTS test areas (designated as individual CAUs. The regional model constituted Phase I of the UGTA project. The CAU-specific models, of which up to four are planned (geographically covering each of the six former NTS testing areas), comprise Phase II. To date, one has been built: Frenchman Flat (IT 1998b). The Yucca Flat models are in progress. The more detailed CAU-specific groundwater-flow and contaminant-transport models will be used to determine contaminant boundaries based on the maximum extent of contaminant migration. The results of the individual CAU groundwater models will be used to refine a monitoring network to ensure public health and safety.

In 2000, the UGTA Project drilled a total of three wells in two different drilling initiatives.
Well ER-EC-2A, located offsite just west of the NTS, and south of Pahute Mesa, was completed early in 2000. This was the last in a series of eight hydrogeologic investigation wells drilled in the Western Pahute Mesa - Oasis Valley (WPM-OV) area of Nye County, Nevada (IT 1998a). The goal of the WPM-OV drilling program, initiated in 1999, was to collect subsurface geologic and hydrologic data in a large, poorly characterized area down-gradient from Pahute Mesa, where underground nuclear tests were conducted, and up-gradient from groundwater discharge and withdrawal sites in Oasis Valley northeast of Beatty, Nevada (see Figure 7.3). Data from these wells will allow for more accurate modeling of groundwater flow and radionuclide migration in the region. Some of the wells may also function as long-term monitoring wells.

Hydrological tests and sampling were completed in 2000 at all seven wells drilled under this program (one onsite and six offsite, located just west of the NTS). Groundwater characterization samples were collected from each of these wells, and no man-made radionuclides were detected.

In 2000, the UGTA Project initiated a hydrogeologic investigation well drilling program in the Frenchman Flat CAU in the southeastern portion of the NTS, Nye County, Nevada (IT 2000). The goal of this program is to collect additional subsurface geologic and hydrologic data in the Frenchman Flat CAU, where ten underground nuclear tests were conducted between 1965 and 1971 (DOE 2000) (see Figure 7.5). Data from these wells will allow for more accurate modeling of groundwater flow and radionuclide migration in this former test area. Some of the wells may also function as long-term monitoring wells.

Two new wells were drilled under the Frenchman Flat drilling program during 2000 (Wells ER-5-3 and ER-5-3 #2). These wells were completed in the alluvial and volcanic aquifers, and the regional carbonate aquifer. Preliminary (predevelopement) groundwater characterization samples were collected from each of these wells. No man-made radionuclides were detected in these wells.

4.7 HYDROLOGIC RESOURCES MANAGEMENT PROGRAM

The NNSA's Hydrologic Resources Management Program's (HRMP's) primary responsibility is to acquire hydrologic data and information of groundwater supplies to support ongoing activities and to assist in planning new uses for the NTS. The main objective of this program is to provide a sound technical basis for NTS groundwater use decisions regarding the quality and quanitity of water resources available on and around the NTS on a long-term scale.

The Los Alamos and Lawrence Livermore National Laboratories (LANL and LLNL), the U. S. Geological Survey (USGS), and the Desert Research Institute (DRI) participated in the NNSA/NV HRMP. The HRMP is funded by the Defense Programs of NNSA/NV and supports the national security mission at the NTS through studies of radiochemistry and hydrologic science.

The LANL measured water samples for ^{237}Np and continued the evaluaion of colloidal species as a transport mechanism for plutonium and neptunium.

The USGS measured water levels for NTS wells and continued to devlop a steady-state groundwater model for the Death Valley Region, which includes the NTS.

In FY 2000, the HRMP at LLNL conducted three investigations:

- To develop an understanding of radionuclide movement in the unsaturated zone, LLNL investigated the mobility of fallout radionuclides derived from atmospheric nuclear tests north of the NTS in regions known to be actively recharging groundwater.

- LLNL also devised analytical techniques to image the distribution of beta-emitting radionuclides important to defense and remedial activities which rely on the identification of long-lived radionuclides in glass and soil samples.

- Finally LLNL continued studies of the source of regional groundwater for the NTS by investigating the source and amount of recharge in central Nevada.

In support of the HRMP in 2000 DRI performed the following tasks:

- Temperature and video logging of boreholes.

- Discrete state cell (DSC) modeling of the NTS groundwater flow system.

- Trace element geochemistry of the NTS.

POST-SHOT WELLS

In 2000, the UGTA Program sampled the CHESHIRE post-shot/cavity well U-20n PS#1ddh. In general, preliminary results show expected levels of contamination for post-shot wells.

A multi-agency team consisting of personnel from the USGS, LANL, and LLNL collected fluid samples at U-20n PS#1ddh using a downhole sampling pump. The well accesses the test cavity via perforated 5.5 inch casing. During sample collection, field parameters, including temperature, pH, and conductivity were measured. Samples were then analyzed for ^{3}H, ^{14}C, gross alpha and gross beta.

U-20n PS#1ddh was drilled to support studies of radionuclide migration from the cavity/chimney region of the CHESHIRE underground test that was conducted on Pahute Mesa in February of 1976. Radionuclide migration studies at this site have been intermittent since 1976. Samples collected from the lower zone of U-20n PS#1ddh present a unique opportunity to analyze cavity fluids.

The results of this sampling effort at U-20n PS#1ddh will support the NNSA's continuing efforts to create a long-term monitoring program for wells in or near underground nuclear test cavities. The program objectives are to characterize the hydrologic source term and evaluate the decay and potential migration of radionuclides through monitoring at or near the source.

Other accomplishments of the UGTA Program in 2000 include the development, testing and sampling of eight characterization wells in the Western Pahute Meas - Oasis Valley study area. These wells were drilled in 1999 and early 2000 (one onsite and seven offsite, located just west of the NTS). No man-made radionuclides were detected in these wells.

GROUNDWATER QUANTITY

Water levels are monitored annually by the USGS on and around the NTS at approximately 140 measurement locations, including 66 onsite and 74 offsite locations. Results are used in regional and local groundwater models, but are not routinely analyzed for water level trends. However, no significant water level impacts associated with groundwater usage were detected in 2000.

Water usage on the NTS is monitored by both the USGS and BN. Water use at the NTS continues to decline due to the moratorium on nuclear testing instituted in 1992 and was about 8.18×10^{5} m^{3} (216.2×10^{6} gal) in 2000. Data for the 2000 water year for water levels and usage will be reported in the USGS "Water Resources Data Nevada Water Year 2000" report (Jones *et al.*, 2000) and is also available on the USGS website: www.nevada.usgs.gov.

FALLOUT RECHARGE STUDIES

HRMP at LLNL has begun a study of the migration of fallout radionuclides in mountain soils north of the NTS. The high mountain regions of central Nevada, approximately 200 kilometers north of the NTS, have been identified as recharge zones for the regional groundwater flow system (Rose *et al.*, 1999; Davisson *et al.*, 1999). Preliminary results on fallout nuclide distribution in a soil profile from this area (Currant Summit Spring site) indicates that ^{137}Cs has penetrated to at least 12 cm depth, and that its activity profile with depth can not be modeled as a simple exponential function. At least two rate constants are required to describe the cesium soil profile. This phenomenon has been observed previously in studies of plutonium penetration into NTS soils where two different components of plutoniumu-migration have been identified (Shinn *et al.*, 1993). Such behavior may be the result of differential migration of different size particles.

The total amount of ^{137}Cs deposited at the Currant Summit Spring site is 48 nCi/m^2. This value, determined from integration of the ^{137}Cs depth profile, is consistent with other surface deposition measurements for this part of central Nevada. Plutonium is also expected in the soil samples collected from Currant Summit but is not detected by gamma spectroscopy. From the plutonium isotopic composition, it should be possible to determine the relative contributions of local NTS verses global fallout. This may be important if the plutonium depth profile indicates a multi-component migration as described above for cesium. Results are pending. ^{241}Am was not detected by gamma spectrometry in the Currant Summit Spring site soil. It will also be measured by MC-ICP-MS.

The processes by which fallout radionuclides penetrate mountain soils may be similar to those operating in the unsaturated or vadose zone around NTS underground test cavities. Physical and chemical movement may occur during periods of saturated flow from episodic wetting events. Due to greater precipitation and spring snowmelt, such episodic wetting will undoubtedly occur more often in the case of the mountain soil profiles than at the NTS. As such, the radionuclide migration rates defined by fallout studies in such areas should allow limits to be placed on migration rates within the vadose zone at the NTS. In addition, the purpose of this study remains the investigation of how bomb pulse signatures are acquired in the regional groundwater flow system.

RADIOGRAPHY STUDIES OF NUCLEAR DEBRIS

During FY 1998 and FY 1999, HRMP completed work to develop an alpha (α) radiography technique for application to geologic and nuclear melt glass samples (Smith *et al.*, 1999; Eaton and Smith 2000). The results of this work showed that by modifying an existing α-radiography technique, it was possible to spatially resolve areas of high α-activity in melt glasses. The ability to determine where radionuclides are distributed in nuclear melt glass has implications for understanding how radionuclides are released into the environment. Ongoing research involves determining the source of colloidal plutonium, which has been documented to be mobile in fractured volcanic rock aquifers (Kersting *et al.*, 1999). Eaton and Smith (2000) show that a secondary alteration layer of clay (probably smectite) forms on melt glass surfaces, which may be a source of colloidal material. Radiography techniques described here can be subsequently adapted to determine the association of plutonium and colloids.

The success in accurately siting areas of α-activity in thin sections of nuclear melt glass prompted additional research into finding a companion beta (β) radiography application for use with both geologic and melt glass samples. While traditional approaches rely on bulk counting techniques to identify β-emitting isotopes, no method for spatially resolving β-emissions is routinely employed. For the FY 2000 study, HRMP modified an existing β-radiography technique for use with geologic samples, giving a clear and literal picture of the distribution of both high and low β-activities. Both these α- and β-radiography techniques were subsequently applied to nuclear melt glass and geologic samples from the Rainier Test (RT). The RT was chosen for this study because there is a relatively large availability of nuclear melt glass from the RT, and the geology and melt glass from the RT have been extensively studied (e.g., Schwartz *et al.*, 1984; Thompson and Misz 1959).

Polished thin sections were made from each of three melt glass samples and a background volcanic tuff sample. Samples were mounted in epoxy plugs and cut with a precision wafer saw to expose their cross-sectional area before being mounted on circular slides, ground to ~30 µm thickness, and then finished to a high polish. The α-radiography analyses were made using TASTRAK CR-39 detectors, placed directly onto the thin section surface, which were then etched using a sodium hydroxide solution. Refer to Smith *et al.*, (1999) for details of this method.

The beta-radiography method applied in this study was originally developed for use in the biomedical field, where beta-radiography is commonly used to determine the location of

In 1997, the Nevada Division of Water Resources (DWR) issued revised regulations for water-wells and related drilling, which expanded its regulations to address a category of boreholes that are drilled for purposes other than evaluating or producing water. In March 1998, a letter from the NNSA/NV Manager to the President and General Manager of BN stated that compliance with the revised DWR regulations will achieve the goal of protecting groundwater resources from contamination, as well as satisfy state of Nevada and SDWA objectives. The NNSA/NV tasked BN to develop a plan for the management of all existing wells and boreholes and the construction of new wells and boreholes at the NTS in a manner that procedurally meets state regulations. The result of this effort was the NTS Well and Borehole Management Plan (BN 1999).

This plan discusses the objectives/intent of the DWR regulations and how these objectives will be applied to the management of the existing NTS well and borehole inventory, and the construction and management of future wells and boreholes. The objectives include the prevention of contamination or waste of the groundwater resource during the drilling, construction, or plugging of wells and boreholes; drilling, construction, and plugging programs designed to isolate zones of poor-quality water from zones of good-quality water; isolation of artesian zones; and prevention of surface contamination and unauthorized entry. A detailed strategy and process for plugging of the existing unused wells and boreholes is provided within the plan because open wells and boreholes represent a significant potential risk for impacting the quality of the groundwater resource. The process produces a prioritized list of open NTS wells and boreholes that should be plugged, with corresponding cost estimates and tentative schedules (BN 1999).

During September 2000, seven unused boreholes were plugged in Areas 3 and 5 under this plan. Additional unused or abandoned boreholes will be plugged each fiscal year under this multi-year initiative.

4.9 INDUSTRIAL SITES PROJECT

The Industrial Sites Project includes areas located on the NTS and the Tonopah Test Range that were used to support past testing operations. Over 1,500 of these historic areas, or industrial sites, have been identified, verified, and inventoried for characterization, closure, and/or restoration. Of these, nearly 750 sites have been formally closed. The remaining sites have been grouped according to source of contamination, location, and other technical characteristics. Industrial Sites Project activities focus on the characterization and applicable corrective actions for these sites.

The D&D process is also included under the Industrial Sites Project. This process supports the cleanup of the six remaining surplus facilities transferred from the NNSA/NV Defense Programs to the Environmental Restoration Division. These facilities include the Pluto Facility; Super Kukla Facility; RMAD Facility; Engine Maintenance, Assembly, and Disassembly Facility; Test Cell A; and Test Cell C.

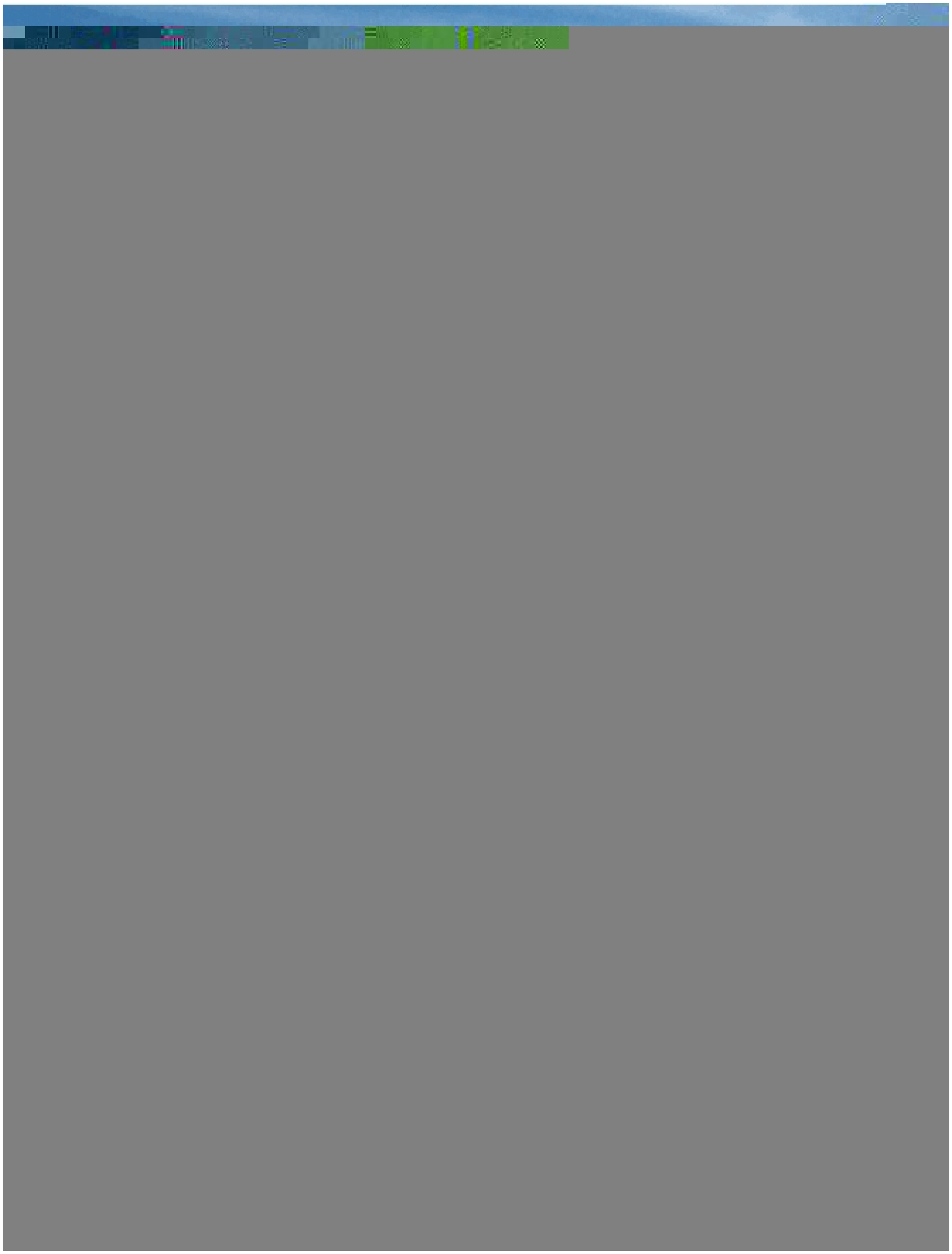
Deactivation is the process used to remove radioactive, chemical, or other hazardous contamination from facilities, structures, soils, or equipment. Methods of deactivation include washing, scraping, or cleaning. Decommissioning involves stabilizing, reducing, or removing radioactive and/or other types of contamination and can consist of dismantling a facility, entombing or covering part or all of the facility, or converting a facility for other uses.

Table 4.1 Pollution Prevention Results, Reduction in Volume and Toxicity of Hazardous Waste - 2000

Activity	Accomplishment	Reduction
Recycle/Reuse	Lead acid batteries shipped offsite to be recycled.	21.38 mt
Recycle/Reuse	Lead scrap metal sold for recycle/use.	16.87 mt
Recycle/Reuse	Sent spent fluorescent light bulbs, mercury lamps, metal hydride lamps, and sodium lamps offsite to be recycled.	6.20 mt
Recycle/Reuse	Bulk used oil was sent off site to be recycled.	54.00 mt
Recycle/Reuse	Hazardous and nonhazardous chemicals, supplies, and equipment were either redistributed for reuse or returned to the vendor for recycling through the material exchange program.	1.13 mt
Recycle/Reuse	Lead tire weights were reused instead of being disposed of as hazardous waste.	0.87 mt
Recycle/Reuse	Rechargeable batteries were sent to an offsite vendor for recycle.	1.74 mt
Source Reduction	Biodegradable corn starch packing peanuts were purchased instead of styrofoam peanuts.	0.10 mt
TOTALS:		**102.29 mt**

Table 4.2 Ongoing Recycling Activities - 2000

Activity	Waste Type	Quantity (Metric Tons)
Mixed Paper	Solid	232.64
Aluminum Cans	Solid	1.13
Food Waste and Grease	Solid	4.21
Electronic Media	Solid	2.56
Lead Tire Weights Reuse	Hazardous	0.96
Material Exchange	Solid/Hazardous	1.13



Frenchman Flat in the Spring (No Date Provided)

5.0 RADIOLOGICAL ENVIRONMENTAL PROGRAMS

The radiological environmental surveillance at the Nevada Test Site (NTS) addresses compliance with U. S. Department of Energy (DOE) Orders, state and federal regulations, stakeholder issues and other drivers as defined in the Routine Radiological Environmental Monitoring Plan (RREMP). The radiological compliance monitoring brings together sitewide environmental surveillance, site-specific effluent monitoring, and operational monitoring conducted by various missions, programs, and projects on the NTS. Monitoring used a decision-based approach to identify the environmental data that must be collected and provided Quality Assurance, Analysis, and Sampling Plans which ensure defensible data are generated. Sampling and analysis plans provide for monitoring five media in the environment onsite and offsite: air, water, soils (not collected in 2000), plants, and animals. Oversite environmental surveillance is conducted for stakeholders by Desert Research Institute (DRI) of the University and Community College System of Nevada. This program consists of a network of monitoring stations operated by offsite residents. During 2000, no radioactivity related to current activities at the NTS was detected by environmental surveillance programs.

5.1 AIR SURVEILLANCE ACTIVITIES

The air surveillance network on and around the NTS monitors for radionulcides to demonstrate compliance with the Clean Air Act (for a complete description, see Chapter 4.0). Air monitoring was conducted for radioactive particulates and tritiated water (HTO) vapor at 33 locations. The onsite air sampling locations and the ambient gamma radiation monitoring locations relative to the sites with potential for airborne radioactive emissions are shown in Figure 5.1. An insert in this figure also shows the locations of the offsite air sampling locations.

In the following sections, each description of the sampling or monitoring method is followed by a summary of the analytical results and a discussion of the results. The highest annual average concentration for each radionuclide is compared to its derived concentration guide (DCG) for the general public as specified in Federal regulations. This DCG is the concentration that will deliver a 10 mrem/yr effective dose equivalent (EDE), assuming that the receptor resides at the sampling location throughout the year.

AIR PARTICULATE SAMPLING

Air particulate samplers are operated at 33 locations on the NTS. A constant volume of air is drawn through a 9-cm (3.5 in) diameter Whatman GF/A glass-fiber filter at approximately 85 L/min (3 cfm) to trap particulates from the air. The particulate filter are mounted in a filter holder that faced downward at a height of 1.5 m (5 ft) above ground. A run-time clock measured the operating time. The run time, multiplied by 85 L/min yields the volume of air sampled, which is about 860 m^3 (30,000 ft^3) during a typical seven-day sampling period. In CY 2000, flow and subsequent volume were calibrated to standard temperature and Pressure in order to make results directly comparable over the various elevations data collected on the NTS. Historically, ambient air calibrations were done at the elevation where data were collected.

The 9-cm diameter filters are analyzed for gross alpha and gross beta radioactivity no sooner than 5 days after collection to allow for the decay of naturally-occurring radon and its progeny. The filters from four weeks of sampling were composited, analyzed by gamma spectroscopy, and then analyzed for plutonium isotopes. Beginning in March, the monthly composited filter samples were also analyzed for ^{241}Am.

Large volume air samplers were operated offsite at six locations drawing air at a constant rate of 68 m^3/hr through a (type FPAE-810) 20 x 25 cm (8 x 10 inch) glass-fiber filter. The filter is positioned upward and is covered to protect it from the wind and rain. The total volume (approximately 11,400 m^3 (400,000 ft^3) over a seven-day sampling period) and the elapsed time is summed by a microprocessor, which also maintains the constant flow rate. Increasing the volume of air sampled by a factor of 10 allowed greater sensitivity (i.e. lower detection limits) in looking for radionuclides of interest and greater sensitivity as required to confirm the concentrations predicted by modeling efforts. The operation of the high-volume air samplers were terminated during the first week of October 2000 after confirming the conceptual model and to focus resources on source term monitoring on the NTS. The Community Environmental Monitoring Program (CEMP) continues to collect offsite data as oversite verification of the results of source term monitoring.

The 20 x 25 cm filters were analyzed by gamma spectroscopy at least five days after collection, composited over an approximate one-month period, and analyzed for plutonium (also for americium beginning in March).

Gross Alpha and Beta Results

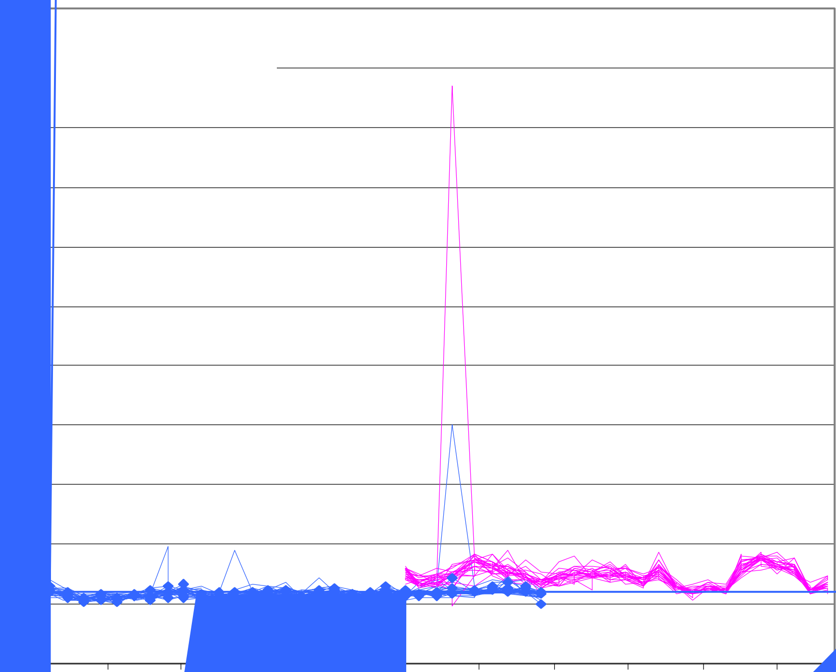
The measurement of gross alpha and gross beta radioactivity in airborne particulates, after the decay of radon progeny, is used as a weekly screening and trending of long-lived radionuclides in air. During 2000, a total of 1,028 air filters were collected weekly and analyzed for alpha and beta radioactivity, before monthly composite analysis. Descriptive statistics for the gross alpha and beta results, in units of µCi per mL of air, are given in Tables 5.1 and 5.2, respectively. The variation in the gross alpha and gross beta radiation measurements during the year is shown in time series plots in Figures 5.2 and 5.3, respectively. As shown in Figure 5.2, the gross alpha concentrations in air were relatively constant. The exceptions were results from Bunker 9-300, a source term that has been recognized previously.

A step increase in all the gross alpha results were realized from the contractor laboratory which were a factor of 3-5 higher than the Bechtel Nevada (BN) results. Possible contributors to the factor of 3-5 difference is due to either equipment background differences or the variations in the configuration of equipment. Since there is no DCG for gross alpha radioactivity, these data are used for weekly screening and trending so investigating the exact cause of this difference is not warranted, but is suspected of being laboratory differences.

In Figure 5.3, the gross beta results from both laboratories are shown in a time series plot. Except for the one sample in August (this sample was also analyzed by BN and found to have a concentration which was consistent with those for the other locations), the results for all locations varied in a similar pattern, suggesting a systematic difference in the laboratory process, sampling equipment variability, or natural variability.

Plutonium Results

Descriptive statistics for ^{238}Pu are given in Table 5.3, which shows that ^{238}Pu was detected above the minimum detectable concentration (MDC) in 50 percent or less of the samples. The highest annual mean concentration onsite was 9.5 x 10^{-18} µCi/mL (350 nBq/m^3) at Bunker T-4,



which is surrounded by areas with known deposits of radioactive fallout from past nuclear tests. The maximum onsite mean concentration was 47 x 10^{-18} mCi/mL (1.7 nBq/m^3) at Bunker 9-300. The highest average concentration offsite was 1.2 x 10^{-18} µCi/mL (44 µBq/m^3) at Rachel, Nevada, which is 0.04 percent of the DCG for the public.

Airborne concentrations of $^{239+240}$Pu, shown in Table 5.4, were consistently above the MDCs for samples collected from Bunker 3-300, U-3AH/AT N, U-AH/AT S, Bunker T-4, Bunker 9-300, and CLEAN SLATE II, where 90 percent or more of the samples had concentrations greater than the MDC. The highest onsite annual mean concentration, 4.3 x 10^{-16} µCi/mL (16 µBq/m^3), occurred at Bunker 9-300. This concentration is 22 percent of the DCG. The highest offsite mean concentration was 2.5 x 10^{-17} µCi/mL (0.93 µBq/m^3) at Amargosa Valley which is only 1.2 percent of the DCG.

The variation in concentrations for all locations during the year is shown by the time series plot in Figure 5.4, which shows Bunker 9-300 and Bunker 3-300 with the highest maximums. When the $^{239+240}$Pu concentrations at Bunker 9-300 are plotted with the gross alpha concentrations at all locations, as shown in Figure 5.5, the peaks in plutonium concentrations are found to occur on the same dates as the high gross alpha concentrations.

Figure 5.6 shows the trend in the highest annual averages of $^{239+240}$Pu from 1991 to 2000 onsite and offsite and compares them to the DCG. Except for the year 1992, when extensive ground disturbing activity occurred at the Area 3 Radioactive Waste Management Site (RWMS-3), the variation in highest average concentration offsite seemed to follow the variation in the onsite highest average concentration.

Figure 5.7 is a historical time series plot of the annual mean concentrations of $^{239+240}$Pu in air particulates for the years 1970 to 2000 at several locations on Yucca Flat and Frenchman Flat, where many nuclear tests have been conducted in the past. The blue line represents the decreasing trend in $^{239+240}$Pu concentrations over the 30-year period. The decrease is attributed to the termination of nuclear testing and the general reduction of field activities that can cause a resuspension of the plutonium in the surface soil. The red regression line is only for the last ten years, showing how air concentrations have leveled off, probably due to the reduced vehicular traffic on dirt roads and other field activities.

Americium Results

Air filter samples were analyzed for ^{241}Am beginning with the March filter composites. The descriptive statistics of the results are given in Table 5.5. As shown in this table, 90 and 100 percent of the samples collected from Bunker 3-300 and Bunker 9-300, respectively, had concentrations above the MDC. Offsite locations at Alamo and Amargosa had the highest percentage of samples with concentrations above the MDC, 28 and 33 percent respectively. The highest onsite annual mean concentration was 9.7 x 10^{-17} µCi/mL (3.6 µBq/m^3) at Bunker 9-300, which is 5 percent of the DCG for the public. The highest offsite concentration average was 2.1 x 10^{-18} µCi/mL (78 nBq/m^3) at Amargosa Valley, which is about 1 percent of the DCG.

A time series plot of all of the results for 2000 (see Figure 5.8), shows a trend similar to that for the $^{239+240}$Pu results; a peak on July 25 at Bunker 9-300 and low concentrations at the offsite locations.

Gamma-Emitting Radionuclides

^{137}Cs was the only man-made radionuclide detected in the air particulate samples by gamma spectroscopy. The descriptive statistics for those samples are given in Table 5.6. The only locations at which concentrations were above the MDCs of the measurements were at the

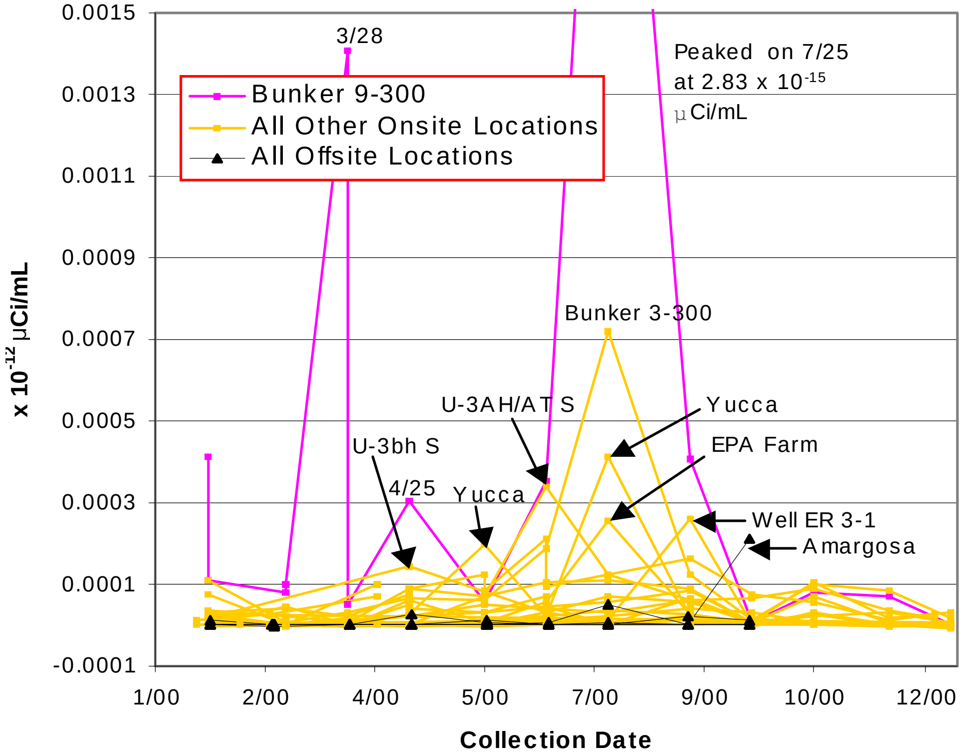


Figure 5.4 Time Series Plot of Plutonium in Air - 2000

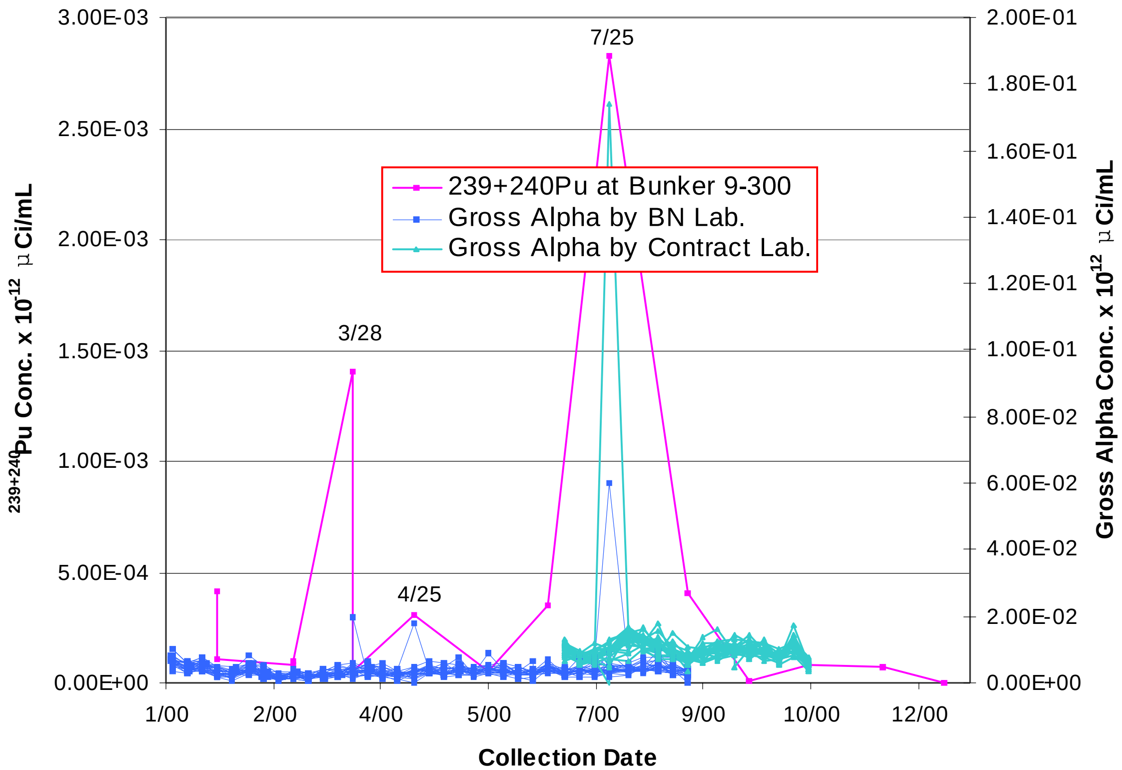


Figure 5.5 Time Series Plot of Plutonium vs Alpha - 2000

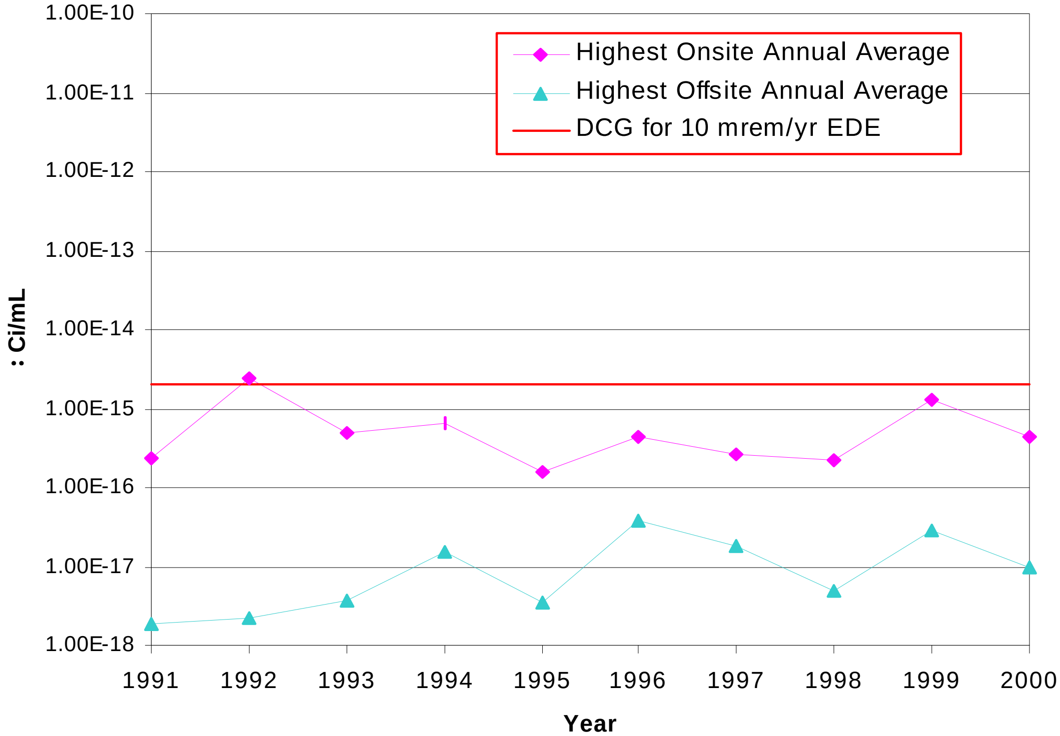


Figure 5.6 Trend in Annual Averages for $^{239+240}$Pu Concentrations

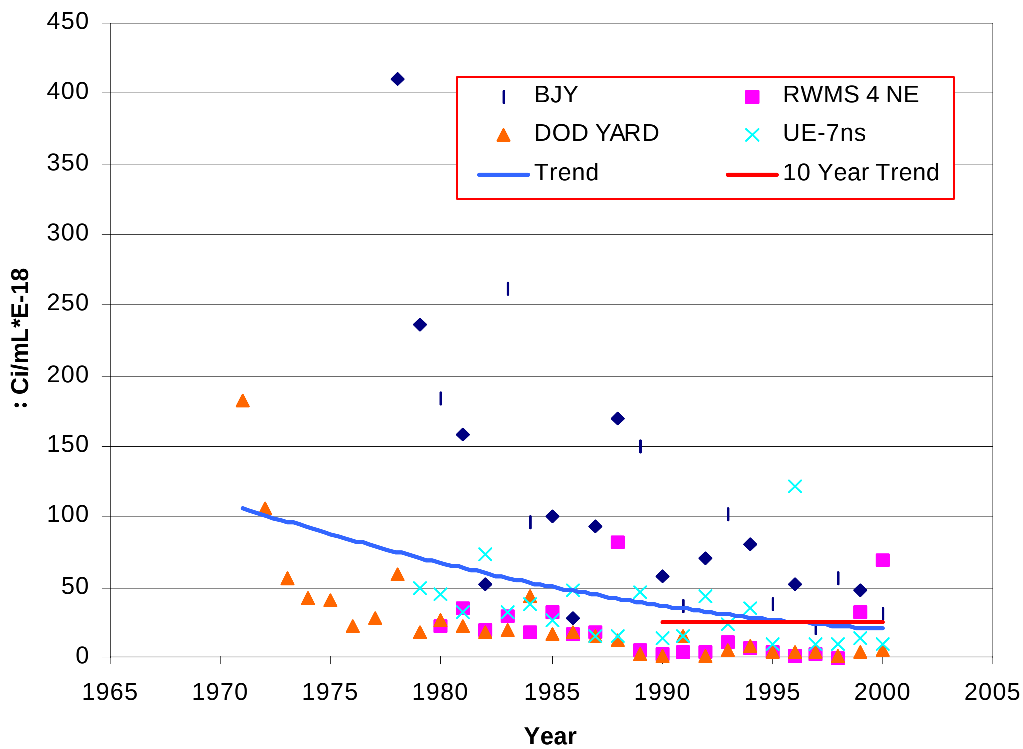


Figure 5.7 Time Series Plot for $^{239+240}$Pu Annual Averages

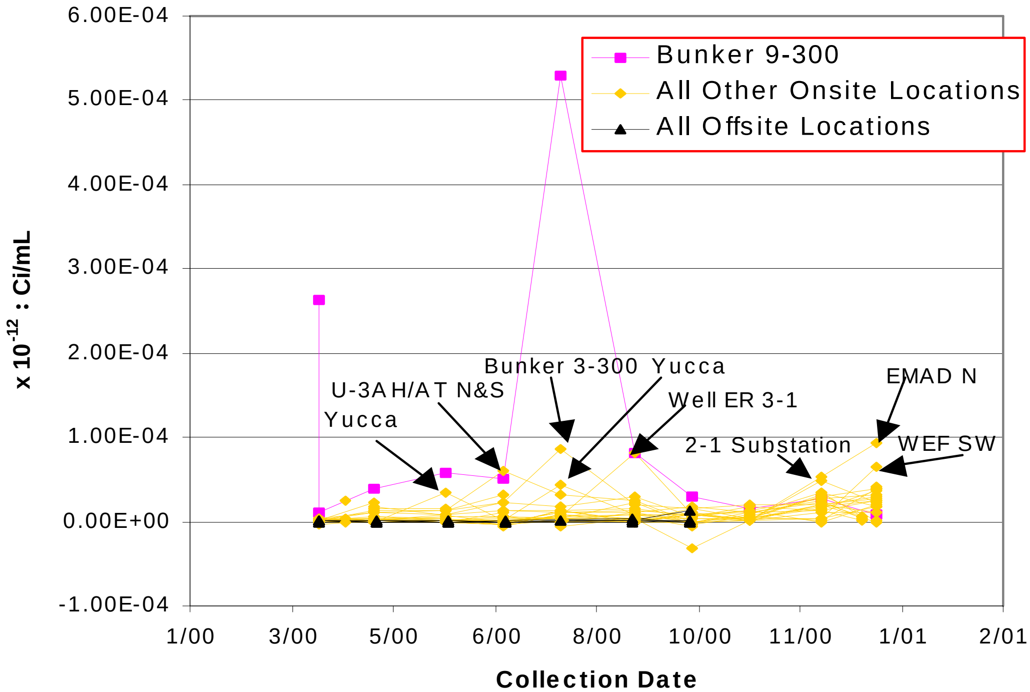


Figure 5.8 Time Series Plot of ^{241}Am in Air All Locations - 2000

The gamma spectroscopy analyses also detect naturally occurring radionuclides in addition to those from nuclear testing. The descriptive statistics for the concentrations of these radionuclides are given in Table 5.7. As the naturally occurring radioactivities from the progeny of radon and thoron (^{208}Tl, ^{214}Pb, ^{226}Ra, ^{228}Ac, and ^{228}Th) are not in equilibrium at the time of counting, they are not reported. The concentrations of ^{7}Be and ^{238}U reported in Table 5.7 are slightly lower than those reported last year. ^{235}U was not detected above the MDC.

TRITIUM IN AIR

Tritiated water vapor in the form $^3H^3HO$ or ^3HHO (HTO) was monitored at 10 onsite locations and two offsite locations. The samplers were operated at a constant flow rate of 0.6 L/min (1.25 ft^3/hr) by microprocessors, which summed the elapsed time and the total volume sampled (about 11 m^3 over a two-week sampling period). At E Tunnel Pond 2 where grid electrical power was not available, a sampler without constant flow capability that summed the air volume sampled with a dry-gas meter had to be used because of the limited power provided by a solar photovoltaic system.

With either sampler, the HTO vapor was removed from the air stream by two molecular sieve columns connected in series (one for routine collection and a second one to indicate if breakthrough occurred during collection). These columns were exchanged biweekly. An aliquot of the total moisture collected was extracted from the columns and analyzed for tritium by liquid scintillation counting.

Tritium in Air Results

A total of 281 samples of atmospheric moisture were collected and analyzed for tritium. Samples were collected at each location throughout the year, except for incidental power outages, equipment malfunctions, and the termination of sampling at the offsite locations (Amargosa and Indian Springs) on October 4, 2000.

RWMS-3 (U-3bh North), Area 5 RWMS (RWMS-5) (Transuranic [TRU] Building and Waste Examination Facility [WEF] Northeast), and Bunker 9-300. The highest annual average concentrations were 2.4 x 10^{-16} µCi/mL (8.9 µBq/m ^{3}) inside the TRU Building and 1 x 10^{-16} µCi/mL (3.7 µBq/m^3) at the environmental location WEF Northeast. Both concentrations were less than 0.01 percent of the DCG

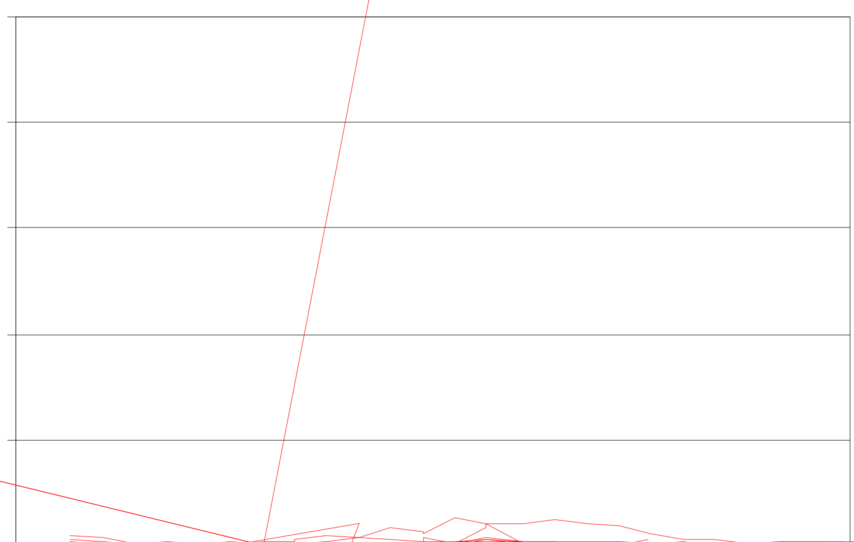
The descriptive statistics of the results, in units of 10^{-6} pCi/mL of air, are shown in Table 5.8. As in the past, the highest annual average HTO concentration, 3.3 x 10^{-4} pCi/mL (12 Bq/m^3), was measured in samples collected at a distance of 0.27 km (0.17 mi) from the cratering test SCHOONER. This concentration is 3.3 percent of the DCG for the general public. Those locations at which tritium was detected in the majority of samples (>50 percent) were SCHOONER (Area 20), SEDAN (Area 10), E Tunnel Pond #2 (Area 12), and RWMS 4 Northeast (Area 5 Waste Operations). SCHOONER was the only location at which 100 percent of the samples had HTO concentrations above the MDC of the measurement, which was most likely due to the sampler being close to the site of the test.

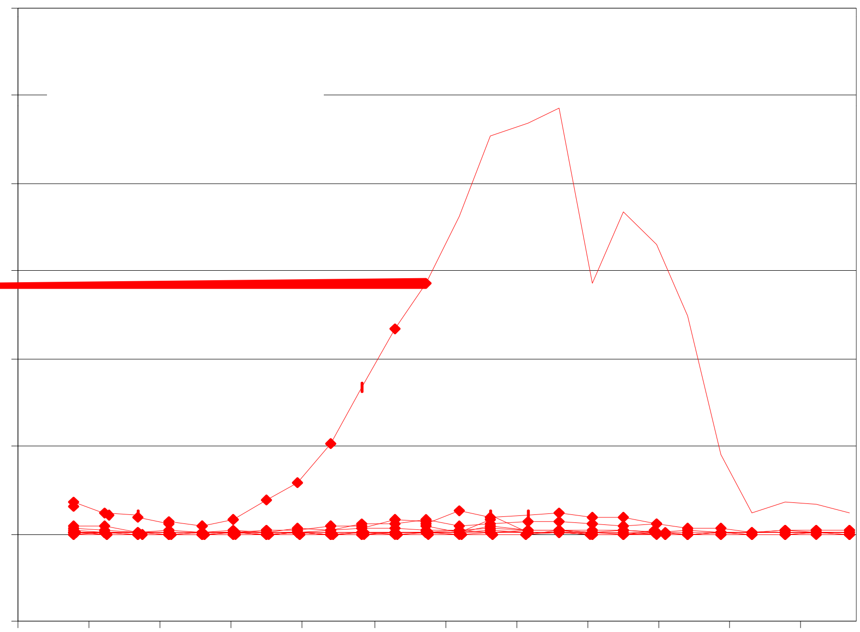
The variations in HTO concentrations at all locations are shown in Figure 5.9. As shown in this figure, the concentrations at all locations rose in the April/May and decreased in November. In Figure 5.10, air temperature appears to be the environmental parameter which affects the release of tritium from the soil and vegetation into the air. The peaking of the airborne tritium at SCHOONER follows the increase of air temperature in the spring and its decrease in the fall.

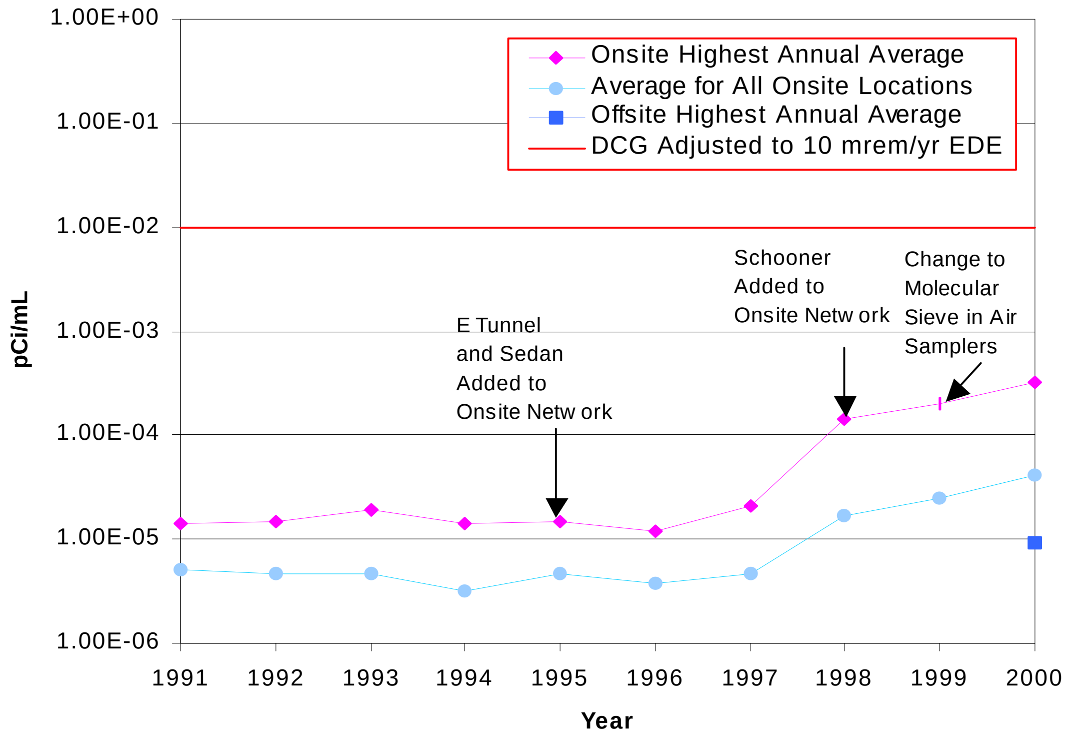
Precipitation in Area 20 is light (8.27 inches in 2000). However, a plot of precipitation with the tritium in air concentrations (Figure 5.11), indicates that heavy rainfall probably influences the variations of airborne tritium. An accurate correlation of rainfall and temperature with airborne tritium concentrations was not possible due to the meteorologic measurements being separate by considerable distances.

The historical trend for HTO concentrations, shown in Figure 5.11, illustrates how changes in sampling locations and equipment effects the average concentrations with time and provides a comparison of highest onsite and offsite average concentrations. The highest annual average concentrations onsite and the annual network averages showed little variation between the years 1991 and 1997, even when samplers were installed near the E Tunnel ponds and the SEDAN crater. However, there was a significant increase in the highest and average network concentrations for the year 1998 when an air sampler was installed near the SCHOONER crater. During 1999, the change to a more efficient desiccant (molecular sieve) contributed to the additional increase observed for that year. The slight increase in the highest onsite average concentration and the network average in 2000 is attributed to the use of molecular sieve for a full year, whereas in 1999 it was used only for half of the year, and to a change in the calibration procedure which corrected the sample volumes for changes in elevation. The single point plotted for the offsite locations in 2000 actually represents data for the years 1999 and 2000. It is included in Figure 5.12 for comparison with the highest onsite averages. Since the two offsite tritium samplers were only operated the last two months in 1999 and the first nine months in 2000, a time-weighted average of the highest offsite averages for the two years was used.

There are five locations that have been in continuous use since 1982 when tritium in atmospheric moisture data first appeared in NTS annual reports. These locations are: BJY, EPA Farm, RWMS 4 Northeast, RWMS 7 West, and RWMS 9 South. Figure 5.13 is a historical time series plot of the median of the annual averages of these five locations. The median was used in this plot because for small sample sizes the median is a more robust estimator of central tendency than is the mean. A linear regression on these data points show an approximately decreasing trend with a half-life of four years which is faster than its radioactive half-live of 12 years. This is expected due to its dispersion within the atmosphere.







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Offsite Highest Annual Average
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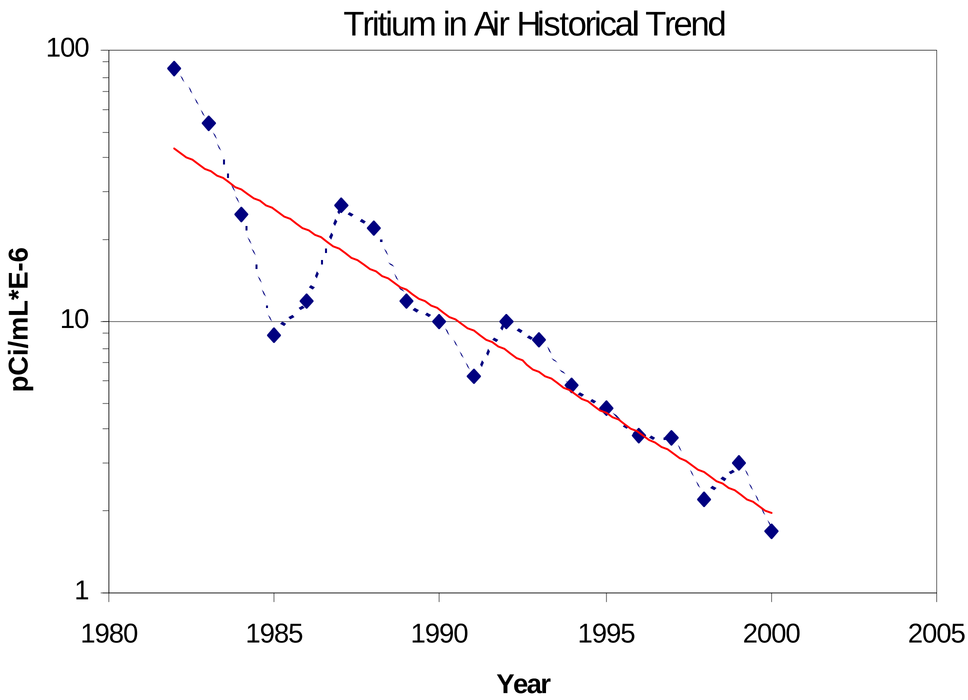

Figure 5.13 Time Series Plot for Tritium in Air on the NTS

5.2 ENVIRONMENTAL DOSIMETRY

AMBIENT GAMMA MONITORING

Film badges were used during early activities on the NTS for ambient gamma exposure monitoring. Thermoluminescent dosimeters (TLDs) replaced the film in 1977, with ten monitoring stations (locations) chosen to be near work sites. From 1977 to 1987, the TLDs used were manufactured by the Harshaw Chemical Company. In 1987, a changeover was made to TLDs manufactured by Panasonic. At the end of 2000, there were a total of 86 active TLD locations. The TLD used was the Panasonic UD-814AS consisting of four elements housed in an air-tight, water-tight ultraviolet-light-protected case. A lithium borate element was slightly shielded in order to measure low-energy radiation. Three calcium sulfate elements were shielded by 1,000 mg/cm^2 of plastic and lead and were used to monitor penetrating gamma radiation. TLDs were deployed in two holders placed about one meter above the ground and exchanged quarterly. Locations were chosen at the site boundary, at locations where historical monitoring has occurred, or where operations or ground contamination have occurred.

THERMOLUMINESCENT DOSIMETER MONITORING DATA

Table 5.9 list the annual total mR/yr for each location. Typically TLDs are exchanged during the first week of each calendar quarter. It takes several work days to exchange all the TLDs, so the exposure duration for each location varies from one quarter to the next. The median exposure in 2000 was 92 days. The range of TLD exposures was from 84 to 113 days.

TLD locations are divided into four classes or sample types, as shown in Table 5.9. Background locations are close to the perimeter of the NTS and in locations known to be relatively free of man-made radionuclide inventory. Operational locations are adjacent to stored radioactive materials in Areas 3 and 5 RWMS and the inactive Decontamination Facility locations. The remaining TLDs are in the environmental monitoring class with a small subset referred to as historical because of the long location history.

A statistical analysis of the data indicate that a log transformation is appropriate for the TLD data. A two-way analysis of variance (ANOVA) found highly statistically significant differences among quarters and among locations, with the location-to-location differences being somewhat more prominent than the temporal differences. Three locations, Stake A-9 (Area 4, E), Stake N-8 (Area 2, E), and RWMS South (Area 3, W), are identified as being distinctly higher than the remaining locations. An additional four locations, SEDAN West (Area 10, E), Bunker 7-300 (Area 7, E), T Tunnel #2 Pond (Area 12, E), and U-3CO North (Area 3, E), were somewhat higher than the remaining locations. These seven locations were also reported with atypical values in the annual report for 1999 (DOE 2000). There remain statistically significant differences among the other locations, although there were no particular clusters, just a continuous distribution involving all the remaining locations. The seven data values that were judged to be atypical are listed in Table 5.10 and are compared with the “Area Mean” for that general NTS area with the atypical values deleted. The locations in Table 5.10 are mostly in Yucca Flat, in places known to be contaminated by early atmospheric nuclear testing, the tunnel ponds containing products from nuclear testing performed within the tunnels, and operations at the Area 3 RWMS.

There are highly statistically significant differences among location Classes on the log scale: the historical location mean, 104 mR/hr, is significantly lower than both the environmental and waste operation means, 173 mR/yr and 159 mR/yr, respectively. The latter two are nearly the same, and the background class mean, 132 mR/yr, is between and not statistically significantly different from the others. Similarly, there are highly statistically significant differences among Areas, with no clustering except that the Area 23 mean is significantly lower than nearly all other Areas.

To evaluate the quarter-to-quarter pattern, a one-way ANOVA was performed on log observations adjusted for location-to-location differences. The result is that the third quarter mean values are systematically around 10-11 percent higher than the mean values for other quarters; the remaining quarters are nearly the same, with the first quarter slightly but not statistically significantly lower.

A nested ANOVA was performed as a follow-up to the location Class and Area analyses. In each case, the conclusion is that there are statistically significant differences among Classes or Areas beyond that due to the differences among locations, but that the additional variation is relatively minor compared with the location-to-location variation. All of the ANOVA conclusions remain qualitatively unchanged when the three or seven locations with highest mean values are omitted.

Comparing the 2000 TLD data with that for previous years, it was found that the median has increased slightly over 1999, from 119 mR/yr to 132 mR/yr, and the low and high values are lower and higher. These analyses are based on the environmental, background, and historical locations combined, omitting the atypical values identified previously. Based upon data from an aerial radiological survey of the NTS by the BN Remote Sensing Laboratory (Hendricks 1999), the median exposure rate of 132 mR/yr is actually lower than the average exposure rate of 165 mR/yr surveyed in the southwestern quarter of the NTS where little fallout from nuclear tests on the NTS has occurred.

The trend in exposure rates during the years 1994 to the present time is shown in Figure 5.14, which is a boxplot of the data by years for the environmental, background, and historical areas. Boxplots consist of a box, whiskers, and outliers. The bottom of the box is at the first quartile, the center line is the median, and the top of the box is the third quartile. The whiskers are lines

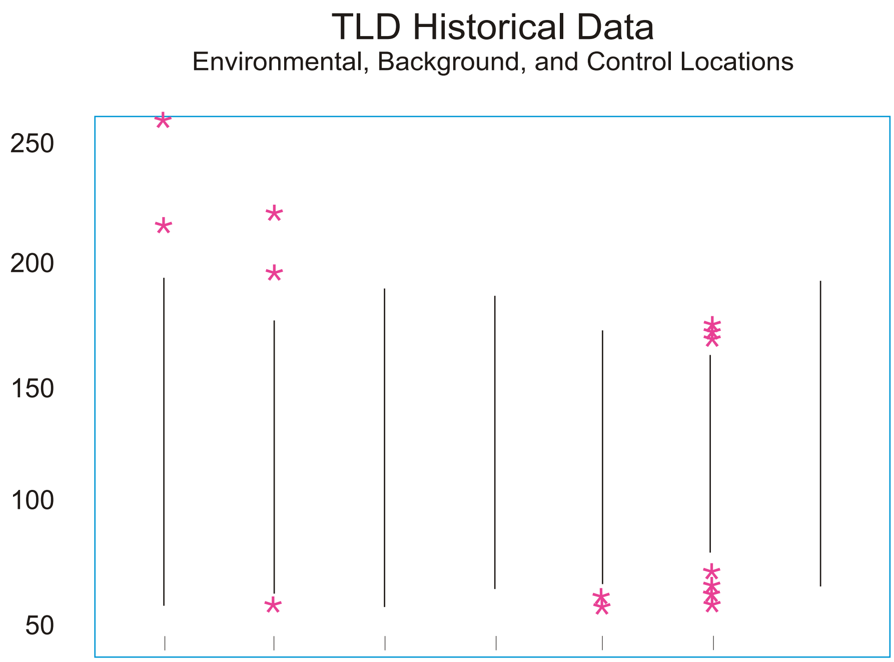

Figure 5.14 Historical Time Series of Boxplots of TLD Exposures

SEWAGE LAGOONS

Each of the sewage lagoons are part of a closed system used for the evaporative treatment of sanitary sewage. The descriptive statistics of the gross beta radioactivity is given in Table 5.12. The annual average gross beta concentration was 28 x 10^{-9} mCi/mL (1.0 Bq/L) which is lower than last year's average of 67 x 10-9 mCi/mL (2.3 Bq/L). No test-related radioactivity was detected by gamma spectroscopy in any of the samples. No radioactivity was detected above the MDC for all ^{3}H, ^{90}Sr, ^{238}Pu, $^{239+240}$Pu, and ^{241}Am analyses.

5.4 BIOTA SURVEILLANCE ACTIVITIES

Biota sampling was implemented during 1999 and is described fully in the RREMP. Five sites were selected for sampling over the next five years. These sites are considered the most contaminated sites and are considered representative of the five types of contaminated sites present on the NTS. These sites include E Tunnel Ponds, Palanquin, SEDAN, T2, and Plutonium Valley. Each site will be sampled once each five years to confirm low radionuclide levels (more frequently and intensely if levels are found to be higher than action levels).

Monitoring in FY 2000 was conducted at two contaminated locations, E Tunnel Ponds, and SEDAN, and a control site, Whiterock Spring (Figure 5.16). E Tunnel Ponds (1,829 meters elevation, 6,000 feet elevation), located in Area 12 in the northern part of the NTS was selected for monitoring because of its historically high levels of contaminated water and soils (DOE 1998a). Vegetation at SEDAN was sampled for radionuclide components that could possibly be ingested by animals and enter the food chain. Whiterock Spring (1,539 meters elevation, 5,049 feet elevation), a naturally occurring spring in Area 12, was selected as an area control site for SEDAN. Vegetation at the Whiterock Spring was described by Hansen et al., (1997).

Collection of samples for the routine radiological monitoring of biota at the NTS commenced on September 21, 2000 and continued through October 16, 2000. A late Summer to early Fall sampling period corresponded to times of the year when tritium levels have been seasonally highest on the NTS (Hunter et al., 1998).

Extensive effort was made to trap rabbits, doves, or chukar from July to October at numerous sites (June/July coincide with abundant species and September/October coincide with migrants moving south, leaving only resident species). Despite an extensive effort, only a single bird was collected and rabbit trapping was unsuccessful during FY 2000, a normal rainfall year. Other sampling protocols are being investigated.

VEGETATION SAMPLING

Woody vegetation was primarily selected for sampling because of a more extensive root system and additionally serves as a major source of browse for wildlife game animals that might eat such vegetation and migrate off site. Grasses and forbs were sampled where species of woody plants were limited.

About 300 to 500 grams (10.6 to 17.6 ounces) of fresh-weight, green-leaf plant material was collected from the current year's growth. All plant samples consist of a composite of material from many plants in the area sampled. Plastic gloves were used by samplers and changed between each sample collected. Green-leaf plant materials from shrubs and forbs were hand-plucked and stored in ziploc-type 3.79 liter (1-gallon) plastic bags. Grasses were sampled by

cutting off plant material with a clean utility knife blade. Samples were labeled with permanent labels on the outside of the bag and stored in an ice chest until delivered to the laboratory (within two hours of collection). Plant samples were delivered to the laboratory under standard chain of custody procedures and frozen until analyzed (DOE 1998a).

Plant samples were taken from the SEDAN site (Figures 5.17 and 5.18) from within 100 meters (109 yards) of the western lip of the crater. Samples taken included representatives of the dominant annuals, grasses, and shrubs at SEDAN. Samples included one grass, desert needlegrass (*Achnatherum speciosa*), one annual, prickley Russian thistle (*Salsola kali*), and two woody shrubs, rubber rabbitbrush (*Ericameria nauseosa*), and fourwing saltbush (*Atriplex canescens*). No trees are present at SEDAN and no tree was sampled. Approximate location of plant samples at SEDAN was: UTM Zone 11, Easting 584480, Northing 4114980. These plants are now existing on soil that was throw out underburden from the initial SEDAN test in 1962.

Plant samples were taken of dominant shrubs at the Whterock Spring control site. These samples included Baltic rush (*Juncus balticus*), Stansbury cliffrose (*Purshia stansburiana*), rubber rabbitbrush *(Ericameria nauseosa*), fourwing saltbush (*Atriplex canescens*), and sandbar willow (*Salix exigua*). One dominant forb, the Louisiana sagewort (*Artemisia ludoviciana*) was sampled at the site. Approximate location of plant samples taken at Whiterock Spring was: UTM Zone 11, Easting 577060, Northing 4117350.

ANIMAL SAMPLING

State and Federal permits were secured to take quail and chukar in addition to doves during FY 2000. Animal trapping in FY 2000 consisted of about 30 trapping days. Trapping effort was directed to mourning doves (*Zenaida macroura*), chukar (*Alectoris chukar*), cottontail rabbits (*Sylvilagus audubonii*) and jackrabbits (*Lepus californicus*). Mourning doves are one of the few game animals that forage on the NTS and migrate offsite, thereby providing a possible pathway of radionuclides in food to man. The ecology of mourning doves is described in detail in (Baskett et al., 1993).

Field observations indicate doves arrive on the NTS during April and numbers increase until about mid August, after which numbers begin to decline. Few doves can be observed on the NTS in October indicating that migration off site is complete. It is reported that a majority of mourning doves in Nevada migrate out of state and end up in south central Arizona (Baskett et al., 1993). Chukars and quail are considered permanent residents of the NTS region. It is not likely that chukars or quail migrate off the NTS. Researchers (TRW 1999) studying quail movements near Yucca Mountain found that one female quail moved a maximum distance of 6.8 km (4.2 mi) from initial point of capture during 59 weeks of monitoring. Resident species such as quail or chukar might accumulate higher levels of activity than migratory species due to their longer residence time on the NTS.

Traps were placed at several sites in FY 2000 to catch birds and rabbits. These included Well 5B Pond, Camp 17 Pond, SEDAN, Whiterock Spring, and E Tunnel Ponds. At each site a minimum of two traps were set to different openings to allow rabbits or birds such as chukar, dove or quail to enter the traps. Trap locations were prebaited for 3-5 days prior to setting traps, to attract animals to each site. Prebaiting consists of applying a large quantity of bait in the area outside of traps to allow animals to consume bait and become adjusted to the presence of traps. Dead shrubs and trees were also used to camouflage and cover the traps to provide shade.

Traps were baited with several types of bird seed, including commercial song-bird seed mixtures with millet, sorghum, sunflower seeds, chopped corn, and commercial rabbit rations. Bait was sprinkled on the ground when applied. No water was provided as part of the bait environment.

Figure 5.17 View of the SEDAN Sampling Site about 100 m West of the Lip of the Crater where Plants were Sampled during October 2000

Figure 5.18 Closeup View of Vegetation (Rubber Rabbitbrush) Sampled at SEDAN about 100 m West of the Crater Edge during October 2000

Traps were baited about 3:00 pm and checked the following morning by about 10:00 am. Because predation of bait by unwanted species was unavoidable, a large quantity of bait was always applied each night to ensure enough bait was present at all times.

Doves were moderately abundant at NTS sites during June-July FY 2000 on both Frenchmann and Yucca Flats, when they were reproducing. Doves were observed to congregate around prebaited traps at Well 5B during late June through early July and several doves were caught and released after 6 days. Sites on northern Yucca Flat, Whiterock Spring, SEDAN, Camp 17 Pond, and E Tunnel Ponds were prebaited later in the year (August -October). An abundance of chukar were attracted to the prebaiting at E Tunnel Pond but a late August rainfall dispersed the birds before they could be caught. Overall only one dove was caught from this effort at E Tunnel Ponds after 10 days of trapping. The approximate location of the dove sample at E Tunnel ponds was: UTM Zone 11, Easting 571740, Northing 4116080. At Camp 17 pond, dove abundance was observed to be low in September and October and none were caught after six days of trapping. At SEDAN and Whiterock Spring no rabbits or doves were caught in approximately eight days at each site, although jackrabbits were observed on several occasions at SEDAN. Natural water is unavailable at SEDAN and no gamebirds were observed on any visit during this time.

Trapping efforts in FY 2000 indicate that birds may be captured easily at sites that are prebaited early in the year (June-July) when birds are abundant. Late season trapping of birds (September -October) when they are dispersed from water or are not abundant on NTS has proved to be very difficult. Shooting doves during September when fewer birds are present would be the preferred method for late season sampling. Rabbits cannot be regularly captured by trapping with bait on NTS. Shooting of rabbits is recommended to successfully obtain samples.

RESULTS

Radionuclide activities in NTS Biota Samples in FY 2000 are shown in Table 5.13. For most samples taken, above background levels of activity were detected for ^{40}K, a naturally occurring radioisotope, at both sites. Three samples tested above MDC for vegetation analyzed for ^{90}Sr at SEDAN. The highest activity detected for ^{90}Sr at SEDAN was (Russian thistle) 4.55 pCi/g (0.17 Bq/g) with detection limits of 0.548 pCi/g. Cesium levels were very low at both sites, with only one sample (desert needlegrass) that was above detection limits for ^{137}Cs at SEDAN with an activity of 0.383 pCi/g (MDC of 0.122 pCi/g).

Four vegetation samples at SEDAN were above MDC for ^{238}Pu and five samples tested above MDC for $^{239+240}$Pu (Table 5.13). All activites for ^{238}Pu and $^{239+240}$Pu were very low at SEDAN. The highest measured value for ^{238}Pu was 0.00902 pCi/g (MDC of 0.00457 pCi/g), and for $^{239+240}$Pu the highest activity was 0.0174 pCi/g with a MDC of 0.00925 pCi/g.

Tritium was detectable in all vegetation samples at SEDAN with highest levels in rubber rabbitbrush with an activity of 3,250,000 x 10^{-9} μCi/mL. Fourwing saltbush had a tritium activity range from a high of 510,000 x 10^{-9} μCi/mL to a low of 306,000 x 10^{-9} μCi/mL. Desert needlegrass had the lowest tritium activity of all shrubs sampled at SEDAN (Table 5.13). This may be due to the shallower rooting depth of grasses as compared to shrubs. Tritium concentrations from water in plants sampled by Hunter et al., (1998) from SEDAN in 1996 varied from about 1.73 to 5.02 x10^{-2} μCi/mL. The levels of tritium in plants during 1996 were roughly 5-15 times higher than the values reported here for FY 2000 and most liklely attibutable to natural variation due to rainfall spurring root growth and draughts causing the plant leaves to wilt.

At Whiterock Spring, eight plant samples tested above MDC for ^{238}Pu and five plant samples had small but detectable quantities of ^{239,240}Pu (Table 5.13). In addition, two plant samples (Baltic rush and Stansbury cliffrose) at Whiterock Spring had detectable amounts of ^{238}U. All activites of radionuclides detected were very low at Whiterock Spring. The highest value for ^{238}Pu in vegetation was for rabbitbrush at Whiterock Spring with an activity of 0.0306 pCi/g (MDC of 0.0112 pCi/g). Similarly, the highest activity for ^{239,240}Pu was found in the Louisiana sagewort with a measured activity of 0.0516 pCi/g (MDC of 0.0105 pCi/g). It is possible that these activities are the result of dust on the outside of the vegetation as uptake of plutonium ^{239}Pu from soil through the roots of plants to leaves is known to be very limited (Romney et al., 1970). These authors also noted that higher levels of ^{239}Pu were found to be in native vegetation from fallout areas on NTS which was assumed to be from external surface contamination. In only one plant sample was tritium detected above MDC at Whiterock Spring. This sample was from fourwing saltbush and was barely above detection limits (257 x 10^{-9} µCi/mL) with an activity of 404 $\pm$ 163 x 10^{-9} µCi/mL. Based on the levels of radionuclides detected in plants at Whiterock Spring, this site will not be adequate as a future control site for sampling biota on NTS but may be investigated further to confirm the questionable results.

The dove sampled at E Tunnel Pond during September had a tritium concentration of 391,400 $\pm$ 7450 x 10^{-9} µCi/mL of tissue moisture. The dove also had low but detectable activities of ^{238}Pu and ^{239,240}Pu. These activities were 0.0299 pCi/g ^{238}Pu and 0.0222 pCi/g ^{239,240}Pu (Table 5.13), with MDC's of 0.0134 and 0.0133 pCi/g, respectively.

For comparison to the tritium concentration measured in the dove sample from FY 2000, the average concentration of tritium in water in E Tunnel Pond # 4 sampled on July 13, 2000, was approximately 879,500 x 10^{-9} µCi/mL. Given that the quantity of tritium found in the dove is a factor of two or more times lower than the pond water, it is reasonabe to assume that doves were drinking from E Tunnel Pond water during late summer. In addition, the average concentrations of ^{238}Pu found in the E Tunnel ponds effluent water sampled on July 13, 2000, was roughly 0.198 x 10^{-9} µCi/mL. Similarly, for comparison to the dove sample, the average concentration of $^{239=240}$Pu in water at E Tunnel Pond #4 was approximately 0.603 x 10^{-9} µCi/mL for this date.

5.5 RADIOLOGICAL DOSE ASSESSMENT

To assure that the general public and the environment do not receive radiation doses above the limits specified in federal and state regulations or international recommendations, the following radiological dose assessment for offsite residents and onsite biota is provided. This assessment is based upon the pathways by which radionuclides on the NTS can reach and deliver a dose to offsite residents, an estimate of the airborne emissions, the concentrations of radioactivity measured in air and surface water samples (Section 5.1), and radiation dose conversion factors specified by federal and international authorities. The pathways by which radioactive emissions and effluents from the NTS can result in radiation doses to offsite residents are:

- Inhalation of resuspended surface soil radioactively contaminated by past nuclear testing at NTS and transported offsite by the winds.
- Inhalation of tritiated atmospheric moisture transported offsite by the winds from the evaporation of the water discharged into containment ponds or ditches and the diffuse transpiration of soil or vegetation moisture at the SEDAN site, the SCHOONER site and the Area 5 Waste Management Facility.

- Ingestion of meat from migratory wild game animals which drink from surface waters and eat vegetation containing test-related radioactivity while residing on the NTS.

- Ingestion of water potentially contaminated by underground deposits of radioactivity created by past nuclear tests.

Since the migration of radioactivity in ground water has not been detected in the past nor in the year 2000 (see Chapter 8.0), the pathways by which offsite residents could receive a radiation dose from current activities on the NTS are limited to the first three pathways. The radiation doses assessed herein are estimates based upon measurements of radioactivity in surface water, air, and wildlife tissue and mathematical models that estimate emissions from the resuspension of surface soils and relate the emissions to potential offsite radiation doses . The following sections identify the potential sources of onsite airborne emissions and liquid effluents containing radioactivity, the estimated quantities released, and the atmospheric diffusion model that is used for calculating the radiation effective dose equivalents (EDEs) received by hypothetical offsite receptors. Also included is an update of the assessment of radiation doses to terrestrial and aquatic biota that was begun in 2000.

RADIOACTIVE EMISSIONS

Known and potential sources of airborne emissions and liquid effluents containing radioactivity are identified and listed in Table 5.14. All sources are on the NTS or NAFR except for Building A-1, which is in North Las Vegas. A brief description of the methods used for estimating the emissions is given below. More details about the sources and methods used is reported separately (Grossman 2001).

Laboratory Sources

The emissions for the laboratory sources are actually the total quantities found on inventory and are assumed released into the air although they were not. Radiological analyses conducted in these laboratories require the use of radiation sources that can be volatilized. Since radioactivity can potentially be released from the handling of radioactive sources and samples in laboratory hoods, all the sources are conservatively assumed to be released.

The tritium emission for Building A-1 was estimated from tritiated atmospheric moisture samples collected during the months of February and December and the rate by which air was exhausted from the rooms. The source of the tritium was the result of an accidental release of ^{3}H in July 1995 at a fixed radiation source range in the basement of Building A-1, where residual contamination has persisted despite considerable efforts to remove it.

Area Sources

The area sources in Table 5.14 are a summation of the estimated radionuclide emissions from the individual areas on the NTS and from several contaminated sites on the NAFR (near offsite). The major sources of tritium as HTO are attributed to the events SCHOONER (Area 20) and SEDAN (Area 12), the E Tunnel ponds (Area 12), a low-level waste burial pit in Area 5 RWMS, and water pumped from RNM-2s into the CAMBRIC ditch in Area 5.

The emissions of HTO from SCHOONER, SEDAN, and Area 5 RWMS were estimated from the CEDE calculated from the annual average concentration of HTO at the nearest air sampling location and by back-calculating with CAP88-PC software (DOE 1997b) to determine what emission rate would be required to produce the CEDE from the air sampling measurement. The emission of HTO from the E Tunnel ponds was determined by multiplying the quarterly measurements of HTO concentrations in the ponds by the water volume discharged assuming that all the pond water evaporated. The emission from the CAMBRIC ditch was estimated from the concentration of HTO measured in the well water and the volume of water discharged; all water was conservatively assumed to evaporate into the air.

The emissions of ^{241}Am and $^{239+240}$Pu were estimated for each NTS area for which an inventory was assessed by past in situ gamma spectroscopy measurements and soil sampling (DOE 1991d). The inventoried amount on the ground surface in curies was used as input to a resupension model (NRC 1983) to estimate the emission rate.

OFFSITE RADIOLOGICAL DOSE ESTIMATES

Dose from Airborne Emissions

The radiation doses to offsite residents from airborne emissions were estimated with CAP88-PC software (Version 2.0), in accordance with Title 10 CFR, Part 61. The estimate is described in detail in a report (Grossman 2001) to the Environmental Protection Agency. The software required the following input:

- The annual emission rates calculated for each point/grouped source (Table 5.14)
- The annual emission rates for each of the NTS areas with surface contamination (Areas 1-11, 12, 13, 15, 16, 17, 18, 19, 20, 30, and 52 [NLVF]) (for brevity, total emissions are summed for all areas in Table 5.14).
- Wind files that were constructed for Mercury, Area 12, Area 20, Yucca Flat, and Area 5 from wind rose and stability array data collected over a 10-year period.
- Location of populated areas within 80 km of the NTS sources of emissions.

The EDEs from each computer run for each emission source were summed for each populated offsite location. The location at which a hypothetical receptor received the highest offsite dose was Springdale, Nevada, where the CEDE was 0.17 mrem/yr.

Dose from Consumption of Wild Game

Although hunting is prohibited on the NTS, there is the remote possibility that animals drinking water and feeding on the NTS could migrate offsite where hunters could harvest them. As described in Section 5.3 only tritium, ^{238}Pu, $^{239+240}$Pu were detected above the MDCs of the measurements in a dove. From the hunting bag limits required by the state of Nevada (10 doves per day with no more than 20 doves in a hunter’s possession at any one time) an estimate of the EDE to a hunter consuming 20 doves per year was made. From the assumptions that the weight of the sampled dove breast tissue (32.7 g) was representative for each of the 20 doves and the moisture content of the tissue was 76.1 percent, the EDE was calculated using a dose conversion factor (DOE 1988) for each of the detected radionuclides. The sum of the estimated EDE for each radionuclide was 0.16 mrem/yr, (1.6×10^{-3} mSv/yr).

Total Offsite Dose to Maximally Exposed Individual (MEI)

A summary of the NTS radiological doses for calendar year 2000 can be found in Chapter 1.0, Table 1.2. Based upon the estimated airborne emissions of radioactivity from the NTS for all possible sources, the maximally exposed individual (MEI) was calculated to be at Springdale, Nevada, 58 km (36 mi) west-northwest of CP-1. The EDE to a hypothetical receptor at this location was calculated to be 0.17 mrem/yr (1.7 x 10^{-3} mSv/yr), which is 0.17 percent of the 10 mrem/yr limit required by NESHAPs (CFR 1989). If the receptor at Springdale was the hunter harvesting and ingesting the doves mentioned in the previous section, the person would have received an additional 0.16 mrem/yr for a total EDE of 0.33 mrem/yr, which is 0.33 percent of the dose limit (DOE 1990b) to the general public.

This calculated dose at Springdale is conservative when compared to the EDE calculated from the average concentrations of $^{239+240}$Pu and ^{241}Am (shown in Tables 5.4 and 5.5, respectively) measured at Beatty, which is about eight miles south of Springdale. The EDE calculated from the Beatty air sampling results was 0.0076 mrem/yr. The Springdale dose is also small compared to the gamma radiation background (152 mR/yr, Table 5.21) measured with a pressurized ion chamber at Beatty by the offsite Community Environmental Monitoring Program (section 5.6).

Onsite Biota Doses

The interim DOE Technical Standard, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (DOE 2000a) has been applied to the NTS to determine whether DOE sponsored activities are meeting the dose limits to aquatic and terrestrial biota recommended by the DOE Biota Dose Assessment Committee (BDAC). This technical standard was derived to assist all DOE activities in complying with the dose limit to aquatic organisms specified by Order DOE 5400.5, "Radiation Protection of the Public and the Environment" and the internationally-recommended dose limits for terrestrial biota. The application of this technical standard will demonstrate whether:

- the absorbed dose to aquatic animals exceeds 1 rad/day (10mGy/day) from exposure to radiation or radioactive material.

- the absorbed dose to terrestrial plants exceed 1 rad/day (10mGy/day) from exposure to radiation or radioactive material.

- the absorbed dose to terrestrial animals will not exceed 0.1 rad/day (1mGy/day(from exposure to radiation or radioactive material.

The graded approach of this technical standard is a three-step process consisting of data assembly, a general screening phase, and, if needed, a more detailed analysis phase. The screening phase consists of determining whether the sum of the ratios of maximum radionuclide concentration in a medium such as soil to a biota concentration guide (BCG) is less than one. If it is, the absorbed dose to biota will be less than the above prescribed limit for terrestrial biota. As an aid to the screening phase, a set of electronic spreadsheets (the RAD-BCG Calculator) was used with the technical standard documentation to calculate and sum the concentration ratios.

In 1999, the screening phase was completed for terrestrial biota on the NTS (DOE 2000) showing that the location with the highest radionuclide concentrations, Area 10, had a ratio of only 0.325, based primarily upon the soil concentrations of ^{90}Sr and ^{137}Cs. Since this ratio was less than one, the dose to terrestrial biota is less than 1 rad/day (10mGy/day). This evaluation was based upon past surveys of NTS surface contamination by in situ gamma spectroscopy measurements and soil sampling and analysis (DOE 1991d).

No natural rivers or streams exist on the NTS, but there is a set of tunnel drainage ponds at the Area 12 E Tunnel that have existed for many years and may support some aquatic organisms. The screening phase to evaluate the dose to aquatic biota there was postponed in 1999 until the radionuclide content of the E Tunnel ponds could be characterized. Sediment sampling of the ponds was delayed until December and due to cold temperatures, the ponds were frozen, making sediment sampling impossible. Therefore, the screening phase was conducted using the maximum radionuclide concentrations of the E Tunnel pond water given in Table 5.11 for ^{3}H, ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239+240}Pu$, and ^{241}Am and using the default concentration values for sediment estimated by the RAD-BCG Calculator for the inputted radionuclide concentrations in the pond water.

The results of the screening phase showed that the sum of the concentration ratios was 6.1, indicating that a more detailed analysis is required to assure that the dose to aquatic and terrestrial biota is less than limits prescribed above. The concentration of ^{137}Cs was the major contributor to the concentration to BCG ratio that caused the ratio of one to be exceeded.

Since the ponds are man-made, the existence of aquatic animals is unlikely. However, there are birds and other animals that find access to the fenced ponds to drink the water. Plants also grow around the ponds. The dove that was trapped in 2000 had concentrations of ^{3}H, ^{238}Pu, and $^{239+240}Pu$ in its breast tissue that were above the MDCs of the measurement (see Table 5.13 and Section 5.4). Plants around the ponds were also found to have detectable concentrations of ^{3}H, ^{137}Cs and ^{90}Sr. From the measured concentrations in the biota tissue (dove and vegetation) and the internal dose conversion factors recommended by the BDAC, the internal dose to the biota was estimated. Table 5.15, which summarizes the results, shows that the doses to the dove and vegetation were, respectively, 0.065 mrad/day (6.5×10^{-5} mGy/day) and 0.045 mrad/day (4.5×10^{-5} mGy/day), which are below the dose limits specified by the technical dose standards for biota.

5.6 COMMUNITY ENVIRONMENTAL MONITORING PROGRAM

The CEMP provides communities surrounding the NTS with radiological and weather data, and is

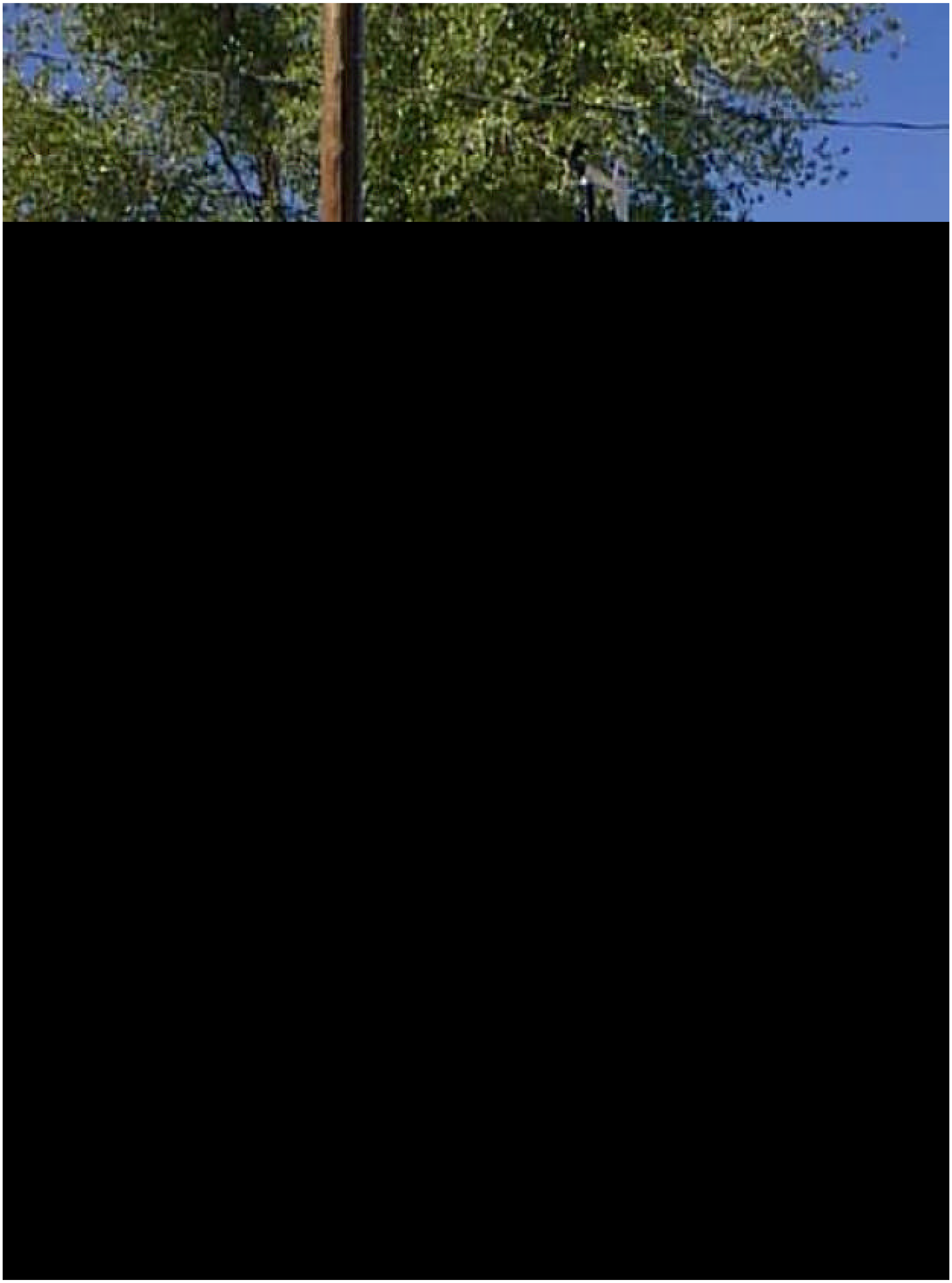

Figure 5.20 The CEMP Station at Beatty, Nevada

feasible. Data storage is designed to allow for 20 days of storage on the datalogger in the event of communication loss. Collected data are transmitted once every three hours to the Western Regional Climate Center (WRCC). The data from the stations are posted on a publicly accessible WRCC web site at http://www.wrcc.dri.edu/cemp.

COMMUNITY ENVIRONMENTAL MONITORS (CEMs)

The primary objective of the CEMP is to involve residents of the communities surrounding the NTS in offsite environmental monitoring. DRI employs local citizens, whose responsibilities include monitoring the equipment, assisting with maintenance, and posting information on the program and analytical results. The Community Environmental Monitors (CEMs) are also part of the chain of custody for the air particulate samples, and are responsible for the weekly collection of air filters and for routing them to DRI, where they are prepared for submission to an independent laboratory for analysis.

Through workshops, the CEMs are trained to independently verify the results of the environmental monitoring, and become knowledgeable spokespersons on subjects ranging from radiation detection to local environmental conditions. They become effective technical liaisons between local and federal entities, helping to identify the environmental concerns of people in their communities.

CEMP AIR SURVEILLANCE NETWORK (ASN)

The inhalation of radioactive airborne particles can be a major pathway for human exposure to radiation. The atmospheric monitoring networks are designed to detect environmental radioactivity from both NTS and non-NTS activities, as well as natural sources. Data from atmospheric monitoring can be used to determine the concentration and source of airborne radioactivity and to project the fallout patterns and durations of exposure to the general public.

During calendar year 2000, the CEMP ASN consisted of 19 continuously operating low-volume air sampling locations. Three additional locations at ranch sites were administered by EPA, but these are expected to come under the purview of the CEMP beginning in September 2001. Duplicate air samples are collected from two routine ASN stations each week. The duplicate samplers are operated at randomly selected stations for three months and moved to new locations.

The glass-fiber filters from the low-volume samplers are received at DRI, then prepared and sent to an independent laboratory to be analyzed for gross alpha and gross beta activity. Samples are allowed to sit for 7 to 14 days after collection to allow time for the decay of naturally occurring radon progeny. Upon completion of the gross alpha/beta analyses, the air filter samples are returned to DRI to be recompiled on a quarterly basis for gamma spectroscopy analysis.

CEMP THERMOLUMINESCENT DOSIMETRY (TLD) NETWORK

External dosimetry is another of the essential components of environmental radiological assessments. This is used to determine both individual and population exposure to ambient radiation from natural or artificial sources. In calendar year 2000, the TLD program consisted of 20 fixed environmental monitoring stations. The primary purpose of the CEMP offsite environmental dosimetry program is to establish dose estimates to populations living in the areas surrounding the NTS. For quality assurance purposes, duplicate TLDs are deployed at two randomly selected environmental stations. An average daily exposure rate was calculated for each quarterly environmental exposure period, and the average of the four values was multiplied by 365.25 to obtain the total annual exposure for each station.

CEMP PRESSURIZED ION CHAMBER (PIC) NETWORK

Laboratory Quality Assurance Samples

Laboratory analyses were performed by Severn Trent Laboratories, St. Louis, Missouri. Quality assurance controls consisted of published laboratory techniques, method blanks, control samples, and duplicates. Method blanks consist of samples that are free of the analyte of interest, and are used to determine if the laboratory itself is contributing to the analysis. Control samples contain a known activity of the analyte and are used to assess the level of accuracy of the analysis. Duplicates in the case of air filter samples are a second analysis of an individual sample. These results indicate the repeatability of the analysis of interest. Except for one gross alpha duplicate analysis, all results fell within acceptable parameters.

AIR SAMPLING RESULTS

The CEMP ASN measures the major radionuclides that could potentially be emitted from activities on the NTS, as well as naturally occurring radionuclides. The ASN represents the possible inhalation exposure pathway for the general public. All glass-filter samples were analyzed for gross alpha and gross beta activity. Upon completion, the samples were returned to DRI and compiled into quarterly composites. The quarterly composites were then analyzed by high resolution gamma spectroscopy.

Gross Alpha

Gross alpha analysis was performed on all low-volume network samples. The annual average gross alpha activity was $2.7 \pm 1.3 \times 10^{-15}$ Ci/mL (101 ± 48 Bq/m^3). A summary of the results is shown in Table 5.18. As in previous years, the results exceeded the analytical MDC and overall showed similar values.

Gross Beta

Gross beta analysis was also performed on all low-volume network samples. As in previous years, these results also exceeded the analytical MDC. The annual average gross beta activity was $2.4 \pm 0.8 \times 10^{-14}$ Ci/mL ($9.0 \pm 3.0 \times 10^{-4}$ Bq/m^3). A summary of the results is shown in Table 5.19. The results overall showed similar values to previous years' data.

Gamma Spectroscopy

Gamma spectroscopy analysis was performed on all samples from the low-volume network samples. The air-filter samples were combined by station on a quarterly basis after gross alpha/beta analysis. This results in the analysis of up to 13 air filters simultaneously for gamma activity. All samples were gamma spectrum negligible (i.e., no gamma-emitting radionuclides detected) relative to ^{137}Cs, the main calibration point.

TLD RESULTS

There were 20 offsite environmental stations monitored with TLDs in 2000. The total exposure for 2000 ranged from 45 mR (0.45 mSv) per year at Pahrump, Nevada, to 112 mR (1.12mSv) at Milford, Utah, with a mean annual exposure of 79 mR (0.79 mSv) per year for all operating locations. All results are shown in Table 5.20 and are consistent with recent years' results.

PRESSURIZED ION CHAMBER (PIC) RESULTS

The PIC data presented in this section are based on daily averages of gamma exposure rates from each station. Table 5.21 contains the maximum, minimum, and standard deviation of daily averages for the periods during 2000 when telemetry data were available. It also shows the average gamma exposure rate for each station during the year, as well as the total mR/yr. The mean ranged from 68 to 152 R/yr. Background levels of environmental gamma exposure rates in the United States (from the combined effects of terrestrial and cosmic sources) vary between 49 and 247 mR/yr (BEIR III 1980). Averages for selected regions of the United States have been compiled by the U.S. Environmental Protection Agency (EPA), and are shown in Table 5.22. The annual exposure levels observed at the CEMP stations are well within these United States background levels.

Table 5.1 Descriptive Statistics for Gross Alpha in Air (x 10^{-15} µCi/L) - 2000

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
1	BJY	52	5.812	4.561	3.48	1.108	15.255	85.6
2	2-1 Substation	51	5.578	4.598	3.53	0.061	13.730	75.5
3	Bunker 3-300	52	5.919	4.742	3.53	0.879	15.948	86.5
3	U-3ah/at N	51	5.926	5.441	2.99	0.757	15.073	93.1
3	U-3ah/at S	51	6.223	4.915	3.65	0.884	15.336	89.2
3	U-3bh N	51	5.904	5.145	3.07	0.378	12.526	90.2
3	U-3bh South	35	7.306	6.307	3.75	2.152	14.746	85.7
3	Well Er 3-1	52	5.804	4.384	3.79	0.744	15.176	82.7
4	Bunker T-4	50	5.818	4.870	3.35	0.880	15.027	93.0
5	DOD	52	5.586	4.544	3.54	1.241	15.832	89.4
5	RWMS TRU Building	34	5.229	4.827	2.18	1.991	10.764	91.2
5	RWMS 4 Northeast	52	6.114	4.983	3.81	1.519	16.380	88.5
5	RWMS 7 West	52	6.485	5.959	3.08	1.260	15.475	94.2
5	WEF Northeast	52	5.757	4.905	3.52	0.502	16.743	83.6
5	WEF Southwest	52	5.942	5.050	3.24	1.372	16.734	94.2
6	Yucca	52	6.497	5.695	3.69	1.247	16.637	90.4
7	UE7nS	52	5.518	4.491	3.48	0.572	15.990	83.6
9	Bunker 9-300	52	9.217	6.071	15.76	1.184	116.958	87.5
10	SEDAN North	51	6.186	5.493	3.54	1.146	15.243	92.2
15	EPA Farm	52	5.471	4.843	3.16	0.748	14.687	79.8
18	LITTLE FELLER 2 N	34	7.002	6.337	3.48	2.550	17.389	97.1
20	CABRIOLET	52	5.394	4.477	3.20	1.119	14.387	81.7
20	SCHOONER	51	5.775	4.705	3.60	1.140	17.707	87.2
25	E-MAD N	52	5.947	4.849	3.68	0.962	15.458	81.7
All Onsite Locations		**1187**	**6.084**	**5.059**	**4.73**	**0.061**	**116.958**	**87.5**
	NAFR Locations							
13	Project 57	15	3.296	3.136	1.42	1.481	6.513	73.3
52	CLEAN SLATE II	13	3.839	3.546	1.66	1.581	7.391	76.9
52	CLEAN SLATE III	13	4.012	3.231	1.97	1.313	8.678	61.5
All Near Offsite Locations		**41**	**3.695**	**3.379**	**1.67**	**1.313**	**8.678**	**70.7**
All Measurements		**1228**	**6.004**	**4.970**	**4.68**	**0.061**	**116.958**	**86.9**

Table 5.2 Descriptive Statistics for Gross Beta in Air (x 10^{-14} µCi/L) - 2000

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
1	BJY	52	2.185	2.012	0.846	0.808	5.075	100.0
2	2-1 Substation	51	2.160	1.892	0.961	0.710	5.487	100.0
3	Bunker 3-300	52	2.229	2.061	0.859	0.943	4.642	100.0
3	U-3ah/at N	51	2.048	1.855	0.766	0.938	4.117	100.0
3	U-3ah/at S	51	2.203	2.006	0.884	0.811	5.049	100.0
3	U-3bh N	51	2.320	1.999	1.243	0.970	8.979	100.0
3	U-3bh South	35	2.340	2.201	0.853	0.891	4.649	100.0
3	Well ER 3-1	52	2.202	1.927	0.890	0.763	4.268	100.0
4	Bunker T-4	50	2.136	1.892	0.856	0.794	4.765	100.0
5	DOD	52	2.185	2.042	0.874	0.868	4.531	100.0
5	RWMS TRU Building	34	2.174	2.058	0.754	1.052	4.864	100.0
5	RWMS 4 Northeast	52	2.239	1.991	0.930	0.809	4.450	100.0
5	RWMS 7 West	52	2.292	2.042	0.903	0.940	4.570	100.0
5	WEF Northeast	52	2.142	1.943	0.871	0.778	4.484	100.0
5	WEF Southwest	52	2.176	1.998	0.865	0.815	4.709	100.0
6	Yucca	52	2.382	2.154	0.914	0.876	4.697	100.0
7	UE7nS	52	2.110	2.037	0.797	0.854	4.013	100.0
9	Bunker 9-300	52	2.272	2.251	0.913	0.841	5.673	100.0
10	SEDAN North	51	2.295	2.161	0.916	0.776	5.769	100.0
15	EPA Farm	52	2.076	1.943	0.780	0.893	4.705	100.0
18	LITTLE FELLER 2 N	34	2.343	2.246	1.083	0.884	7.022	100.0
20	CABRIOLET	52	1.979	1.843	0.762	0.859	4.008	100.0
20	SCHOONER	51	2.141	2.021	0.879	0.606	4.257	100.0
25	E-MAD N	52	2.237	2.150	0.948	0.628	4.794	100.0
All Onsite Locations		**1187**	**2.199**	**2.005**	**0.891**	**0.606**	**8.979**	**100.0**
	NAFR Locations							
13	Project 57	15	1.363	1.192	0.668	0.574	3.171	100.0
52	CLEAN SLATE II	13	1.483	1.391	0.571	0.537	2.570	100.0
52	CLEAN SLATE III	13	1.772	1.635	0.609	0.807	3.037	100.0
All Near Offsite Locations		**41**	**1.531**	**1.391**	**0.629**	**0.537**	**3.171**	**100.0**
All Measurements		**1228**	**2.177**	**1.982**	**0.891**	**0.537**	**8.979**	**100.0**

Table 5.3 Descriptive Statistics for ^{238}Pu in Air (x 10^{-18} µCi/mL) - 2000

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
1	BJY	12	3.012	1.520	3.349	0.000	9.890	33.3
2	2-1 Substation	12	1.718	1.130	2.969	-1.100	9.650	16.7
3	Bunker 3-300	12	3.247	1.265	4.690	0.000	13.450	16.7
3	U-3ah/at North	12	2.393	1.120	3.261	-0.600	9.480	25.0
3	U-3ah/at South	12	1.759	0.245	3.129	-0.700	9.130	8.3
3	U-3bh North	12	1.357	0.000	3.453	-1.300	10.620	8.3
3	U-3bh South	9	1.882	1.330	2.750	-1.300	7.430	0.0
3	Well ER 3-1	12	0.990	0.365	2.010	-0.900	6.310	8.3
4	Bunker T-4	12	9.492	8.385	8.287	0.930	29.120	41.7
5	DOD	12	1.734	1.902	3.216	-5.600	7.035	16.7
5	RWMS TRU Building	7	0.921	0.740	2.027	-0.600	5.180	0.0
5	RWMS 4 Northeast	12	1.157	0.000	2.503	-1.300	6.480	8.3
5	RWMS 7 West	12	1.222	0.900	2.128	-0.800	6.930	8.3
5	WEF Northeast	12	1.763	0.088	5.230	-0.600	18.160	8.3
5	WEF Southwest	12	1.327	0.585	2.794	-3.400	7.040	8.3
6	Yucca	12	2.308	0.915	3.319	-0.600	9.050	8.3
7	UE7nS	12	1.191	0.102	1.890	-0.700	5.410	8.3
9	Bunker 9-300	12	8.529	4.018	12.813	0.840	46.690	29.2
10	SEDAN North	12	5.264	5.305	4.334	-1.000	12.660	50.0
15	EPA Farm	12	1.428	0.690	2.155	-1.100	5.640	8.3
18	LITTLE FELLER 2 North	8	2.478	2.015	2.431	0.000	6.620	12.5
20	CABRIOLET	12	1.513	1.420	1.734	-0.700	5.340	5.6
20	SCHOONER	12	2.577	2.080	2.299	0.000	5.980	25.0
25	E-MAD North	11	2.018	0.680	3.748	-0.700	10.890	4.5
All Onsite Locations		**275**	**2.593**	**1.060**	**4.734**	**-5.600**	**46.690**	**15.5**
	NAFR Locations							
13	PROJECT 57	3	-1.110	-0.500	3.228	-4.600	1.770	0.0
52	CLEAN SLATE II	3	0.000	0.000	0.900	-0.900	0.900	0.0
52	CLEAN SLATE III	3	0.060	0.000	0.692	-0.600	0.780	0.0
All Near Offsite Locations		9	-0.350	0.000	1.804	-4.600	1.770	0.0
	Offsite Locations							
95	Alamo	9	0.942	0.220	1.676	0.000	5.030	22.2
95	Amargosa Valley	9	0.554	0.000	0.837	0.000	2.250	11.1
95	Beatty	9	0.630	0.070	0.934	-0.100	2.380	22.2
95	Goldfield	9	0.820	0.090	1.286	0.000	3.650	22.2
95	Indian Springs	9	0.137	0.000	0.229	-0.100	0.590	11.1
95	Rachel	9	1.239	1.050	1.360	-0.100	4.040	33.3
All Offsite Locations		**54**	**0.720**	**0.105**	**1.148**	**-0.100**	**5.030**	**20.4**

Table 5.4 Descriptive Statistics for $^{239+240}Pu$ in Air (x 10^{-18} µCi/mL) - 2000

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
1	BJY	12	30.49	26.84	26.16	3.70	84.81	66.7
2	2-1 Substation	12	12.39	6.26	13.64	-0.40	43.32	58.3
3	Bunker 3-300	12	126.77	75.65	193.52	8.31	718.00	100.0
3	U-3ah/at North	12	69.53	63.66	42.90	17.80	154.52	100.0
3	U-3ah/at South	12	85.19	64.05	92.13	8.23	337.71	100.0
3	U-3BH North	12	21.12	16.98	19.89	2.01	66.78	66.7
3	U-3BH South	9	38.74	25.56	45.77	1.00	143.42	77.8
3	Well ER 3-1	12	26.38	5.72	74.58	0.00	262.91	50.0
4	Bunker T-4	12	33.49	27.83	27.99	3.74	102.81	91.7
5	DOD	12	5.30	2.35	10.36	-5.60	33.22	29.2
5	RWMS TRU Building	7	13.46	3.76	18.31	0.00	46.61	57.1
5	RWMS 4 Northeast	12	3.07	2.28	3.64	-0.90	10.40	16.7
5	RWMS 7 West	12	2.40	1.96	2.30	-1.10	6.68	16.7
5	WEF Northeast	12	2.70	1.10	4.67	-1.65	14.72	8.3
5	WEF Southwest	12	2.19	1.74	3.52	-3.40	11.34	16.7
6	Yucca	12	58.51	6.37	123.88	0.00	411.78	50.0
7	UE7nS	12	10.58	5.00	11.80	0.00	34.15	45.8
9	Bunker 9-300	12	432.16	175.33	783.18	2.06	2825.30	91.7
10	SEDAN North	12	41.77	15.61	43.32	0.49	108.59	75.0
15	EPA Farm	12	37.76	7.17	72.71	-0.70	258.30	58.3
18	LITTLE FELLER 2 North	8	4.85	3.99	3.59	1.06	10.21	25.0
20	CABRIOLET	12	2.24	1.57	2.51	-0.85	7.44	0.0
20	SCHOONER	12	2.03	2.10	2.19	-0.90	5.70	16.7
25	E-MAD North	11	3.65	2.58	3.53	0.00	11.48	31.8
All Onsite Locations		**275**	**45.80**	**6.31**	**188.78**	**-5.60**	**2825.30**	**52.2**
Near Offsite Locations								
13	PROJECT 57	3	57.89	74.90	51.06	0.50	98.27	66.7
52	CLEAN SLATE II	3	34.91	25.04	30.70	10.35	69.33	100.0
52	CLEAN SLATE III	3	0.74	0.78	0.73	0.00	1.45	0.0
All Near Offsite Locations		**9**	**31.18**	**10.35**	**38.83**	**0.00**	**98.27**	**55.6**
Offsite Locations								
95	Alamo	9	7.49	1.36	16.39	0.32	50.94	77.8
95	Amargosa Valley	9	24.78	1.05	70.66	0.00	213.17	77.8
95	Beatty	9	2.00	1.77	1.27	0.00	4.13	77.8
95	Goldfield	9	1.05	0.95	0.69	0.25	2.09	55.6
95	Indian Springs	9	2.82	0.98	4.14	0.16	11.96	66.7
95	Rachel	9	9.90	7.76	8.60	0.96	25.27	77.8
All Offsite Locations		**54**	**8.01**	**1.50**	**29.59**	**0.00**	**213.17**	**72.2**

Table 5.5 Descriptive Statistics for ^{241}Am in Air (x 10^{-18} µCi/mL) - 2000

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
1	BJY	10	11.375	4.892	13.706	-3.600	38.040	45.0
2	2-1 Substation	10	9.775	3.660	15.444	-0.600	49.210	40.0
3	Bunker 3-300	10	23.827	19.535	22.750	1.840	85.510	90.0
3	U-3ah/at North	10	12.863	11.815	7.428	1.930	24.250	65.0
3	U-3ah/at South	10	19.049	12.510	18.877	0.000	59.970	80.0
3	U-3bh North	10	6.068	5.730	7.373	-1.400	23.540	30.0
3	U-3bh South	8	10.320	12.000	7.333	-1.900	17.960	62.5
3	Well ER 3-1	10	14.268	5.355	25.013	-0.700	81.300	50.0
4	Bunker T-4	10	11.519	13.310	7.498	0.650	24.550	60.0
5	DOD	10	8.122	2.535	12.113	-1.800	32.150	35.0
5	RWMS TRU Building	5	2.824	3.260	4.137	-3.500	8.090	0.0
5	RWMS 4 Northeast	10	6.599	2.270	10.373	-3.200	31.680	30.0
5	RWMS 7 West	10	2.577	0.955	6.817	-2.800	20.950	20.0
5	WEF Northeast	10	4.727	2.100	8.565	-3.000	27.393	25.0
5	WEF Southwest	10	8.326	1.415	19.786	0.000	64.080	20.0
6	Yucca	10	15.037	6.710	16.529	-0.600	42.630	40.0
7	UE7nS	10	5.606	2.870	7.979	0.000	26.170	10.0
9	Bunker 9-300	10	97.506	45.105	155.926	8.470	528.280	100.0
10	SEDAN North	10	13.536	12.270	9.129	0.000	30.250	70.0
15	EPA Farm	10	7.244	4.655	11.157	0.000	37.930	20.0
18	LITTLE FELLER 2 North	7	3.066	0.320	6.486	-5.400	10.920	42.9
20	CABRIOLET	10	6.877	1.725	15.294	-10.900	36.753	20.0
20	SCHOONER	10	7.118	3.115	10.724	-3.600	29.670	40.0
25	E-MAD North	10	15.886	1.340	31.966	-3.100	93.380	20.0
All Onsite Locations		**230**	**13.90**	**4.85**	**38.62**	**-10.90**	**528.28**	**43.0**
	Offsite Locations							
95	Alamo	5	0.206	0.210	0.347	-0.300	0.620	0.0
95	Amargosa Valley	7	2.121	0.220	4.903	-0.100	13.210	28.6
95	Beatty	6	0.467	0.260	0.444	0.000	1.060	33.3
95	Goldfield	6	0.163	0.000	0.499	-0.300	1.110	0.0
95	Indian Springs	7	0.239	0.000	0.358	-0.100	0.770	14.3
95	Rachel	6	0.565	0.070	1.640	-0.600	3.820	16.7
All Offsite Locations		**37**	**0.67**	**0.22**	**2.24**	**-0.60**	**13.21**	**16.2**

Table 5.6 Descriptive Statistics for ^{137}Cs in Air (x 10^{-16} µCi/mL) - 2000

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
1	BJY	9	-0.103	0.000	1.528	-3.178	2.079	0.0
2	2-1 Substation	9	0.321	0.000	1.704	-2.723	2.915	0.0
3	Bunker 3-300	9	0.890	0.238	1.283	-0.664	3.297	0.0
3	U-3ah/at North	9	0.029	0.000	1.412	-1.893	2.209	0.0
3	U-3ah/at South	9	1.821	0.735	3.274	-0.728	9.753	0.0
3	U-3bh North	9	1.009	0.000	1.536	-0.235	4.402	11.1
3	U-3bh South	8	0.681	0.314	1.475	-1.313	2.917	0.0
3	Well ER 3-1	9	-0.576	0.000	1.314	-3.001	1.521	0.0
4	Bunker T-4	9	0.320	0.000	1.070	-0.995	2.937	0.0
5	DOD	9	1.102	0.468	1.953	-0.851	5.237	0.0
5	RWMS TRU Building	5	2.404	0.000	5.757	-0.669	12.690	20.0
5	RWMS 4 Northeast	10	1.020	0.000	2.805	-0.955	8.659	0.0
5	RWMS 7 West	9	-0.410	0.000	0.770	-1.723	0.762	0.0
5	WEF Northeast	9	1.109	0.146	2.213	-0.394	6.726	11.1
5	WEF Southwest	9	-0.013	0.000	0.790	-1.385	1.050	0.0
6	Yucca	9	0.460	0.000	1.478	-1.148	4.021	0.0
7	UE7nS	9	-0.120	0.000	1.392	-2.520	1.771	0.0
9	Bunker 9-300	10	0.926	0.000	4.055	-3.058	11.684	10.0
10	SEDAN North	9	0.910	0.000	2.266	-2.348	4.466	0.0
15	EPA Farm	9	0.678	0.078	1.872	-2.163	4.875	0.0
18	LITTLE FELLER 2 North	7	-0.251	0.000	1.533	-3.256	1.502	0.0
20	CABRIOLET	9	0.258	0.000	0.941	-0.411	2.688	0.0
20	SCHOONER	9	0.523	0.064	0.721	-0.351	1.616	0.0
25	E-MAD North	9	0.806	0.000	1.871	-1.145	3.943	0.0
All Onsite Locations		**211**	**0.551**	**0.000**	**2.053**	**-3.256**	**12.690**	**1.9**
	Offsite Locations							
95	Alamo	22	0.908	0.542	1.137	-0.496	3.261	9.1
95	Amargosa Valley	22	0.766	0.034	1.499	-0.614	5.887	2.3
95	Beatty	22	0.578	0.022	1.343	-0.250	6.053	6.8
95	Goldfield	23	0.588	0.094	1.095	-0.915	3.710	8.7
95	Indian Springs	20	0.914	0.000	2.083	-0.110	8.549	12.5
95	Rachel	22	0.910	0.250	1.486	-0.736	4.179	20.5
All Offsite Locations		**131**	**0.774**	**0.067**	**1.442**	**-0.915**	**8.549**	**9.9**

Table 5.7 Descriptive Statistics for Radionuclides Detected in Air Samples by Gamma Spectroscopy (x 10^{-13} µCi/mL) - 2000

Radionuclide	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
Onsite							
^{7}Be	275	1.451	1.416	0.438	0.010	2.338	99.6
^{40}K	114	0.1515	0.1590	0.0437	0.0665	0.3812	83.8
^{238}U	141	0.1073	0.0804	0.1014	0.00	0.5492	0.60
NAFR							
^{7}Be	9	1.471	1.322	0.376	1.034	2.023	100.0
^{40}K	7	0.1263	0.1215	0.0579	0.0691	0.2423	71.4
Offsite							
^{7}Be	234	1.515	1.349	2.719	0.144	42.395	100.0
^{40}K	146	0.0457	0.0428	0.0178	0.0196	0.1318	67.1
^{238}U	90	0.0733	0.0023	0.1447	0.00	0.6396	0.89
All Locations							
^{7}Be	518	1.480	1.368	1.854	0.010	42.395	99.8
^{40}K	267	0.0930	0.0676	0.0615	0.0196	0.3812	74.3
^{238}U	231	0.0940	0.0490	0.1210	0.00	0.6396	0.71

Table 5.8 Descriptive Statistics for Airborne Tritium Concentrations - 2000

Area	Location	Number of Sample	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
^{3}H Concentration (x 10^{-6} pCi/mL)								
Onsite Locations								
1	BJY	25	1.02	0.68	1.35	-1.12	4.12	16.0
5	RWMS 4 Northeast	25	4.38	3.19	3.98	0.21	13.46	62.0
5	RWMS 7 West	24	2.37	0.87	3.87	-1.26	15.57	35.4
5	RWMS 9 South	24	1.21	0.81	2.01	-1.30	9.70	27.1
5	WEF Northeast	23	2.08	0.30	7.92	-1.72	38.10	8.7
5	Well 5B	24	-0.20	-0.02	1.08	-2.63	1.39	0.0
10	SEDAN North	25	18.18	12.23	16.17	1.30	51.41	88.0
12	E Tunnel Pond No. 2	22	12.95	11.79	10.54	0.58	30.42	86.4
15	EPA Farm	25	5.90	5.55	3.81	1.33	18.66	92.0
20	SCHOONER	26	325.48	149.57	331.11	18.45	972.99	100.0
All Onsite Locations		**243**	**42.21**	**1.66**	**152.56**	**-2.63**	**972.99**	**48.6**
Offsite Locations								
95	Amargosa Valley	19	0.06	0.06	0.93	-1.66	2.60	5.3
95	Indian Springs	18	0.60	-0.36	3.16	-1.95	9.75	11.1
All Offsite Locations		**37**	**0.32**	**0.05**	**2.28**	**-1.95**	**9.75**	**8.1**

Table 5.9 Descriptive Statistics for TLD Annual Exposures, (mR/yr) - 2000

Area	Location	Sample Type	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
1	BJY	(a)	4	109	110	11	96	119
1	Bunker 1-300	(a)	4	131	130	5	127	139
1	Sandbag Storage Hut	(a)	4	120	119	3	118	124
1	Stake C-2	(a)	4	129	128	11	118	144
2	Stake L-9	(a)	4	192	187	12	183	209
2	Stake M-140	(a)	4	141	140	9	132	152
2	Stake N-8	(a)	4	748	745	43	704	798
2	Stake TH-58	(a)	4	101	101	4	97	104
3	A3 RWMS Center	(d)	4	173	174	12	158	187
3	LANL Trailers	(a)	4	122	121	7	116	131
3	RWMS East	(d)	4	156	156	5	150	161
3	RWMS North	(d)	4	131	129	9	121	143
3	RWMS South	(d)	3	481	465	34	458	519
3	RWMS West	(d)	4	132	132	9	121	142
3	Stake A-6.5	(a)	4	156	157	10	142	168
3	Stake OB-11.5	(a)	4	136	134	6	132	146
3	Stake OB-20	(a)	4	93	92	5	87	98
3	U-3Co North	(a)	4	235	232	22	214	264
3	U-3Co South	(a)	4	171	167	12	162	187
3	Well ER 3-1	(a)	4	134	135	8	123	140
4	Stake A-9	(a)	4	895	893	47	840	953
4	Stake TH-41	(a)	4	117	115	5	113	124
4	Stake TH-48	(a)	4	127	124	5	123	134
5	3.3 Miles SE of Aggregate Pit	(b)	4	67	66	4	62	72
5	Building 5-31	(a)	4	121	121	7	111	129
5	RWMS East Gate	(d)	4	160	162	9	148	168
5	RWMS Northeast Corner	(d)	4	124	123	7	117	134
5	RWMS Northwest Corner	(d)	4	137	137	7	128	144
5	RWMS South Gate	(d)	4	121	119	9	112	133
5	RWMS Southwest Corner	(d)	4	128	127	7	121	138
5	Water Well 5b	(c)	4	120	118	8	114	131
5	WEF East	(d)	4	130	129	6	125	138
5	WEF North	(d)	4	126	126	5	120	132
5	WEF South	(d)	4	132	131	6	127	141
5	WEF West	(d)	4	145	146	12	131	157
6	CP-6	(c)	4	77	77	2	74	79
6	DAF East	(a)	4	98	97	5	93	104
6	DAF West	(a)	4	93	91	6	86	101

(a) Environmental Locations.
(b) Background Locations.
(c) Historical Locations.
(d) Waste Operations.

Table 5.9 (Descriptive Statistics for TLD Annual Exposures, [mR/yr] - 2000, cont.)

Area Location	Sample Type	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
6 Decon Facility Northwest	(a)	4	134	128	16	121	157
6 Decon Facility Southeast	(a)	4	136	136	4	131	141
6 Yucca Oil /Storage	(a)	4	104	105	3	101	107
7 Bunker 7-300	(a)	4	286	288	11	271	296
7 Reitmann Seep	(a)	4	133	133	6	127	138
7 Stake H-8	(a)	4	135	137	7	126	141
8 Road 8-02	(a)	4	135	134	7	128	144
8 Stake K-25	(a)	4	110	109	4	106	115
8 Stake M-152	(a)	4	178	177	9	170	189
9 Bunker 9-300	(a)	4	129	129	5	124	136
9 Papoose Lake Road	(c)	4	84	83	4	81	89
9 U-9CW South	(a)	4	107	104	6	104	117
9 V & G Road Junction	(a)	4	125	125	7	117	133
10 Circle & L Roads	(a)	4	124	123	6	118	132
10 Gate 700 South	(c)	4	137	134	8	132	149
10 SEDAN East Visitor Box	(a)	4	142	141	8	134	153
10 SEDAN West	(a)	4	295	293	15	281	313
11 Stake A-21	(a)	4	136	135	5	132	144
12 Gold Meadows Spring	(b)	1	159	159	.	159	159
12 T-Tunnel No.2 Pond	(a)	4	258	258	19	241	274
12 Upper Haines Lake	(a)	4	123	124	7	114	131
12 Upper N. Pond	(a)	4	135	134	4	131	140
15 EPA Farm	(a)	4	117	114	7	113	127
15 U-15E Substation	(b)	4	100	99	5	96	107
18 Stake A-83	(a)	4	148	148	7	140	158
18 Stake F-11	(a)	4	150	149	9	140	161
19 Gate 19-3P	(b)	2	105	105	105	31	179
19 Stake C-27	(b)	3	163	168	19	142	180
19 Stake P-41	(a)	4	169	167	9	161	180
19 Stake P-77	(a)	3	173	177	21	151	192
19 Stake R-26	(b)	3	169	167	14	156	184
20 Stake A-118	(b)	4	158	155	10	149	170
20 Stake J-31	(a)	4	193	190	14	179	211
20 Stake J-41	(a)	4	145	145	8	138	154
20 Stake LC-4	(b)	3	175	172	15	162	192
22 Army #1 Water Well	(b)	4	86	85	4	84	92

(a) Environmental Locations.
(b) Background Locations.
(c) Historical Locations.
(d) Waste Operations.

Table 5.9 (Descriptive Statistics for TLD Annual Exposures, [mR/yr] - 2000, cont.)

Area	Location	Sample Type	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
23	Building 650 Dosimetry	(c)	4	64	65	3	61	67
23	Building 650 Roof	(c)	4	58	58	2	57	61
23	Mercury Fitness Track	(a)	3	75	85	20	51	87
23	Post Office	(c)	4	84	77	16	74	107
25	Gate 25-4-P	(b)	4	141	139	7	136	151
25	Guard Station 510	(b)	4	136	134	7	130	145
25	HENRE	(c)	4	133	130	7	129	143
25	Jackass Flats & A-27	(b)	4	87	86	5	82	94
25	NRDS Warehouse	(c)	4	133	130	9	127	146
25	Yucca Mountain	(b)	4	145	143	7	141	155
27	Cafeteria	(c)	4	145	141	10	137	158
30	Junction Cat Can Buggy Rd	(b)	4	188	186	12	176	205
	Summary by Sample Type							
	Environmental	(a)	190	173	133	145	51	953
	Background	(b)	48	132	141	42	31	205
	Historical	(c)	40	104	110	33	57	159
	Waste Operations	(d)	51	159	134	83	112	519
	All Locations		**346**	**151**	**132**	**118**	**27**	**953**

(a) Environmental Locations.
(b) Background Locations.
(c) Historical Locations.
(d) Waste Operations.

Table 5.10 Listing of Atypical TLD Data Values - 2000

Area	Location	Location Mean	Mean for Other Locations in Area
4	Stake A-9 [(a)]	895	122
2	Stake N-8 [(a)]	748	144
3	RWMS South [(d)]	481	139
10	SEDAN West [(a)]	295	134
7	Bunker 7-300 [(a)]	286	134
12	T-Tunnel No. 2 Pond [(a)]	258	132
3	U-3Co North [(a)]	235	139

(a) Environmental Locations.
(b) Background Locations.
(c) Historical Locations.
(d) Waste Operations.

Table 5.11 Descriptive Statistics for Radioactivity in E Tunnel Effluent and Ponds ($x 10^{-9}$ µCi/mL) - 2000

Radionuclide	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
Gross Beta	12	67.38	67.85	4.89	56.00	73.70	100
^{3}H	16	850000.00	881000.00	79345.00	714000.00	943000.00	100
^{90}Sr	4	0.96	0.76	0.46	0.66	1.65	50
^{137}Cs	16	170.00	195.00	195.00	57.40	258.00	100
^{238}Pu	16	0.35	0.34	0.22	0.07	1.02	100
$^{239+240}Pu$	16	2.80	2.66	1.66	0.57	7.55	100
^{241}Am	4	0.29	0.29	0.05	0.24	0.35	100

Table 5.12 Descriptive Statistics for Gross Beta Radioactivity in Sewage Lagoons - 2000

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
5	RWMS Sewage Pond	3	32.18	38.30	11.38	19.05	39.20	100.0
6	DAF Sewage Pond	3	27.97	24.90	14.05	15.70	43.30	100.0
6	LANL Sewage Pond	3	44.97	51.30	11.49	31.70	51.90	100.0
6	Yucca Sewage Pond	3	20.50	21.80	2.97	17.10	22.60	100.0
22	Sewage Pond	2	42.25	42.25	12.52	33.40	51.10	100.0
23	Sewage Pond	2	17.08	17.08	0.25	16.90	17.25	100.0
25	Central SP	1	9.34	9.34	-	9.34	9.34	100.0
25	Reactor Control SP	2	16.50	16.50	4.52	13.30	19.70	100.0
All Locations		**19**	**28.31**	**22.60**	**13.85**	**9.34**	**51.90**	**100.0**

Table 5.13 Radionuclide Activities in NTS Biota Samples - 2000

Location	Common Name	Scientific Name[a] Genus	Species	$\%H_20$ (%)	Concentration x 10^{-9} µCi/mL Tritum[b]	^{40}K	^{137}Cs	^{90}Sr[b]
PLANT SAMPLES								
Sedan Crater								
100m west of crater	desert needlegrass	*Achnatherum*	*speciosa*	12.6	61,800 ± 1,850	3.16 ± 2.02	0.383 ± 0.157	0.377 ± 0.226c
100m west of crater	desert needlegrass	*Achnatherum*	*speciosa*	15.6	63,900 ± 1,660	2.58 ± 2.48(c)	0 ± 0.275(c)	0.424 ± 0.275(c)
100m west of crater	fourwing saltbush	*Atriplex*	*canescens*	25.6	306,000 ± 5760	48.2 ± 7.96	0.124 ± 0.212(c)	0.392 ± 0.332(c)
100m west of crater	fourwing saltbush	*Atriplex*	*canescens*	30.3	510,000 ± 9,320	59.9 ± 10.3	0.0723 ± 0.181(c)	0.0624 ± 0.279(c)
100m west of crater	rubber rabbitbrush	*Ericameria*	*nauseosa*	26.1	3,250,000 ± 57,300	19.1 ± 8.23	0.136 ± 0.239(c)	0.164 ± 0.13(c)
100m west of crater	rubber rabbitbrush	*Ericameria*	*nauseosa*	20.2	2,780,000 ± 49,100	17.2 ± 8.66	0.104 ± 0.263(c)	0.449 ± 0.22
100m west of crater	prickly russian thistle	*Salsola*	*kali*	44.7	325,000 ± 6,030	55.7 ± 11.8	0.04 ± 0.359(c)	4.55 ± 1.42
100m west of crater	prickly russian thistle	*Salsola*	*kali*	32.1	72,200 ± 1,580	72.8 ± 11.1	0.122 ± 0.156(c)	0.715 ± 0.402
Whiterock Spring								
50m south of spring	Louisiana sagewort	*Artemisia*	*ludoviciana*	52.4	3.5 ± 152(c)	15.6 ± 8.29	0.298 ± 0.377(c)	0.0266 ± 0.142(c)
50m south of spring	Louisiana sagewort	*Artemisia*	*ludoviciana*	39.2	-12.5 ± 156(c)	17.9 ± 7.8	0.175 ± 0.318(c)	-0.035 ± 0.133(c)
50m south of spring	fourwing saltbush	*Atriplex*	*canescens*	23.4	404 ± 163	52 ± 5.94	0.0549 ± 0.12(c)	0.0339 ± 0.212(c)
50m south of spring	fourwing saltbush	*Atriplex*	*canescens*	36.4	-40.1 ± 151(c)	70.3 ± 6.97	-0.0386 ± 0.13(c)	0.227 ± 0.255(c)
50m south of spring	rubber rabbitbrush	*Ericameria*	*nauseosa*	32.3	0 ± 152(c)	11.7 ± 7.69	0.0697 ± 0.498(c)	0.0045 ± 0.13(c)
50m south of spring	rubber rabbitbrush	*Ericameria*	*nauseosa*	27.6	-86.3 ± 147(c)	16.4 ± 10.2	0.209 ± 0.818(c)	0.0000686 ± 0.104(c)
50m south of spring	Baltic rush	*Juncus*	*balticus*	28.2	-117 ± 141(c)	13.8 ± 5	-0.112 ± 0.177(c)	0.222 ± 0.204(c)
50m south of spring	Baltic rush	*Juncus*	*balticus*	45.3	-97.6 ± 151(c)	11.3 ± 5.33	-0.0546 ± 0.198(c)	0.142 ± 0.145(c)
50m south of spring	Stansbury cliffrose	*Purshia*	*stansburiana*	26.4	-5.1 ± 147(c)	5.72 ± 4.05	-0.121 ± 0.176(c)	0.0173 ± 0.0776(c)
50m south of spring	Stansbury cliffrose	*Purshia*	*stansburiana*	20.5	-117 ± 147(c)	8.35 ± 3.35	-0.0234 ± 0.153(c)	0.036 ± 0.0878(c)
50m south of spring	sandbar willow	*Salix*	*exigua*	27.9	-101 ± 149(c)	10 ± 4.38	0.162 ± 0.208(c)	0.022 ± 0.164(c)
50m south of spring	sandbar willow	*Salix*	*exigua*	31.5	-74.5 ± 221(c)	10.6 ± 5.32	-0.000212 ± 0.177(c)	0.0809 ± 0.198(c)
ANIMAL SAMPLES								
E Tunnel Ponds								
50m north of ponds	Mourning dove	*Zenaida*	*macroura*	54.7	391,400 ± 7,450	No data	0.373 ± 0.255(c)	0.269 ± 0.446(c)

± Error is the 2.0 Sigma Error, % H20 is the approximate percent water of sample on a dry weight basis, 40K is a naturally occurring radiosotope.

(a) U. S. Department of Agriculture. 1996. The PLANTS database. National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

(b) Activity levels result from subtracting background levels and may occasionally yield negative values.

(c) Value was less than Minimum Detectable Activity.

Table 5.13 (Radionuclide Activities in NTS Biota Samples - 2000, cont.)

Location	Common Name	Scientific Name[a] Genus	Species	$\%H_2O$ (%)	Concentration, pCi/g ^{238}Pu[b]	$^{239+240}Pu$[b]	^{241}Am[b]	^{235}U	^{238}U
PLANT SAMPLES									
Sedan Crater									
100m west of crater	desert needlegrass	*Achnatherum*	*speciosa*	12.6	0.00386 ± 0.00604(c)	0.00616 ± 0.0096(c)	0.211 ± 0.384(c)	0 (c)	0 (c)
100m west of crater	desert needlegrass	*Achnatherum*	*speciosa*	15.6	0.00836 ± 0.00697	0.0142 ± 0.00811	0.442 ± 0.648(c)	0.737 ± 0.795(c)	0 (c)
100m west of crater	fourwing saltbush	*Atriplex*	*canescens*	25.6	0.00437 ± 0.0063	0.0101 ± 0.0094(c)	0.184 ± 0.717(c)	0.702 ± 1.01(c)	0.747 ± 4.9(c)
100m west of crater	fourwing saltbush	*Atriplex*	*canescens*	30.3	0.00902 ± 0.00846	0.00912 ± 0.00734	-0.491 ± 0.494(c)	0.232 ± 0.679(c)	3.15 ± 4.09(c)
100m west of crater	rubber rabbitbrush	*Ericameria*	*nauseosa*	26.1	0.00191 ± 0.00536(c)	0.0174 ± 0.00904	0.726 ± 1.03(c)	0.0836 ± 1.6(c)	0.639 ± 9.01(c)
100m west of crater	rubber rabbitbrush	*Ericameria*	*nauseosa*	20.2	0.00538 ± 0.00499	0.0143 ± 0.00757	-0.362 ± 1.3(c)	0.377 ± 1.14(c)	0.452 ± 15.7(c)
100m west of crater	prickly russian thistle	*Salsola*	*kali*	44.7	0.00881 ± 0.00904(c)	3.46E-10 ± 0.00698(c)	0.356 ± 1.35(c)	0.177 ± 0.86(c)	0.955 ± 11.5(c)
100m west of crater	prickly russian thistle	*Salsola*	*kali*	32.1	0.00345 ± 0.00556(c)	0.00507 ± 0.00499	0.553 ± 1.04(c)	0 (c)	2.09 ± 7.38(c)
Whiterock Spring									
50m south of spring	Louisiana sagewort	*Artemisia*	*ludoviciana*	52.4	0.0117 ± 0.00731	0.0168 ± 0.00857	-0.348 ± 1.56(c)	0.395 ± 1.49(c)	9.65 ± 11.3(c)
50m south of spring	Louisiana sagewort	*Artemisia*	*ludoviciana*	39.2	0.0196 ± 0.0102	0.0516 ± 0.016	-0.189 ± 1.11(c)	0.76 ± 1.68(c)	10.4 ± 9.64(c)
50m south of spring	fourwing saltbush	*Atriplex*	*canescens*	23.4	0.0291 ± 0.00564(c)	0.00288 ± 0.00565(c)	0.285 ± 0.348(c)	0.201 ± 0.909(c)	4.24 ± 3.02(c)
50m south of spring	fourwing saltbush	*Atriplex*	*canescens*	36.4	-0.00278 ± 0.0106(c)	0.00135 ± 0.00591(c)	-0.147 ± 0.674(c)	-0.234 ± 0.539(c)	2.73 ± 7.69(c)
50m south of spring	rubber rabbitbrush	*Ericameria*	*nauseosa*	32.3	0 (c)	0.00373 ± 0.00367	-0.485 ± 0.478(c)	0 (c)	0 (c)
50m south of spring	rubber rabbitbrush	*Ericameria*	*nauseosa*	27.6	0.0306 ± 0.0126	0.00202 ± 0.00281(c)	1.84 ± 2.14(c)	2.2 ± 1.81(c)	14 ± 28.3(c)
50m south of spring	Baltic rush	*Juncus*	*balticus*	28.2	0.0115 ± 0.00719	0.00176 ± 0.00423(c)	0.643 ± 1.24(c)	0.448 ± 1.88(c)	7.17 ± 7.27(c)
50m south of spring	Baltic rush	*Juncus*	*balticus*	45.3	0.00485 ± 0.0044	0.00158 ± 0.00311(c)	0.27 ± 0.557(c)	0.033 ± 1.34(c)	11.2 ± 11.2
50m south of spring	Stansbury cliffrose	*Purshia*	*stansburiana*	26.4	0.0144 ± 0.00889	0.0036 ± 0.00409	0.146 ± 0.864(c)	0.438 ± 0.982(c)	13.2 ± 11.4
50m south of spring	Stansbury cliffrose	*Purshia*	*stansburiana*	20.5	0.00609 ± 0.00546	0.00392 ± 0.00473(c)	0.483 ± 0.36(c)	-0.199 ± 0.775(c)	0.238 ± 7.82(c)
50m south of spring	sandbar willow	*Salix*	*exigua*	27.9	0.0151 ± 0.00798	0.00663 ± 0.00495	0.292 ± 0.566(c)	0.315 ± 0.787(c)	5.15 ± 4.35(c)
50m south of spring	sandbar willow	*Salix*	*exigua*	31.5	0.00449 ± 0.0102(c)	0.000589 ± 0.0012(c)	0.368 ± 0.469(c)	0.522 ± 1.71(c)	4.27 ± 8.12(c)
ANIMAL SAMPLES									

Table 5.14 Summary of Annual Radionuclide Emissions by Source [(a)] (Multiply Ci by 37 to obtain Gbq) - 2000

Location	Source Type	Radionuclide	Half-Life (years)	Quantity (Ci)
Area 6, CP-95A Laboratory	Point	^{3}H	12.35	4.6×10^{-5}
Area 6, DAF Laboratory	Point	^{3}H	12.35	5.6
Area 23, Building 650 Laboratory	Grouped	^{3}H	12.35	3.0×10^{-4}
Area 52, Building A-1, North Las Vegas	Point	^{3}H	12.35	0.37
Onsite	Area	^{3}H [(c)]	12.35	426
Total ^{3}H				**431**
Area 23, Building 650 Laboratory (12)[(b)]	Grouped	^{85}Kr	10.72	2.1×10^{-6}
		^{129}I	1.57×10^{7}	5.4×10^{-7}
Onsite	Area	$^{239+240}Pu$	24,065	2.9×10^{-1}
Near Offsite, NAFR	Area	$^{239+240}Pu$	24,065	3.2×10^{-2}
Total $^{239+240}Pu$				**3.2×10^{-1}**
Onsite	Area	^{241}Am	432.2	4.7×10^{-2}
Near Offsite, NAFR	Area	^{241}Am	432.2	2.0×10^{-3}
Total ^{241}Am				**4.9×10^{-2}**

(a) All locations on or near the NTS except Building A-1, which is in North Las Vegas.
(b) (x) is number of vents or stacks.
(c) Emissions based on environmental air sampling data at SCHOONER and SEDAN, tritiated water discharged from the E Tunnel and tritiated water pumped from Well RNM-2s into the CAMBRIC ditch.

Table 5.15 Internal Dose Estimates for E Tunnel Biota - 2000

Biota	Radionuclide	Concentration (pCi/g wet)	Internal Dose Factor (rad/day per Bq/kg wet)	Internal Dose (rad/day)
Dove Breast Tissue	^{3}H	391,000 (pCi/L)[(a)]	4.5×10^{-6}	0.0514
	^{238}Pu	0.0299	5.4×10^{-3}	0.000006
	$^{239+240}Pu$	0.0222	5.4×10^{-3}	0.000004
Total Internal Dose to Dove				**0.065**
Rubber Rabbitbrush	^{3}H	3,250,000 (pCi/L)[(a)]	2.9×10^{-7}	0.0349
Desert Needlegrass	^{137}Cs	0.383	4.3×10^{-5}	0.00061
Prickly Russian Thistle	^{90}Sr	4.55	5.8×10^{-5}	0.0098
Total Internal Dose to Vegetation				**0.045**

(a) Concentration of tritium in water removed from dove or vegetation tissue by vaccum distillation.

Table 5.16 Air Filter Analyses and Techniques

Analyte	Collection Time	Holding Time	Method
Gross Alpha	168 hours	None	DOE RP-710 mod
Gross Beta	168 hours	None	DOE RP-710 mod
Gamma Spectroscopy	Quarterly Composite	None	EPA 901.1 mod

Table 5.17 Results of Field and Laboratory Quality Assurance Samples

Analyte	Number of Field Duplicates	Average %RSD	Number of Laboratory Duplicates	Average %RSD
Gross Alpha	96	15.3	103	13.3
Gross Beta	96	4.3	103	3.1
Gamma ^{7}Be	8	5.3	8	8.4
Gamma ^{210}Pb	8	7.2	8	6.1

Table 5.18 Gross Alpha Results for the Offsite Air Surveillance Network - 2000

Concentration (10^{-15} Ci/mL [37 Bq/m^3])					
Sampling Location	**Number**	**Maximum**	**Minimum**	**Mean**	**Standard Deviation**
Alamo	52	7.7	1.2	3.2	1.6
Amargosa Center	52	7.1	0.5	3.1	1.6
Beatty	52	8.2	0.9	2.8	1.3
Boulder City	52	10.2	1.1	3.6	1.7
Caliente	52	5.1	0.9	2.5	1.1
Cedar City	52	9.0	2.0	3.8	1.3
Delta	50	5.2	0.9	2.2	0.9
Goldfield	52	7.3	0.7	2.6	1.5
Henderson	51	8.2	0.7	2.7	1.4
Indian Springs	49	4.9	0.7	2.1	0.7
Las Vegas	52	5.4	1.0	2.8	1.4
Milford	52	5.4	0.8	2.3	1.0
Overton	50	6.6	1.1	2.9	1.3
Pahrump	52	5.5	0.5	2.2	1.0
Pioche	52	4.8	0.5	2.2	1.0
Rachel	48	8.0	0.9	2.9	1.5
St. George	52	6.6	0.5	2.6	1.3
Tonopah	52	5.5	0.9	2.3	1.0
Mean MDC = 5.6 x 10^{-16} Ci/mL		Standard Deviation of Mean MDC = 1.0 x 10^{-16} Ci/mL			

Table 5.19 Gross Beta Results for the Offsite Air Surveillance Network - 2000

Concentration (10^{-14} Ci/mL [0.37 Bq/m^3])					
Sampling Location	**Number**	**Maximum**	**Minimum**	**Mean**	**Standard Deviation**
Alamo	52	4.1	1.2	2.5	0.7
Amargosa Center	52	6.7	1.2	2.5	1
Beatty	52	5.6	1.4	2.4	0.8
Boulder City	51	6.6	1.2	2.7	1
Caliente	52	4.4	1.2	2.5	0.7
Cedar City	52	4.3	1.4	2.4	0.6
Delta	50	6.3	1.3	2.5	1
Goldfield	52	6.1	0.8	2.4	0.9
Henderson	51	5.2	1.2	2.4	0.8
Indian Springs	49	3.3	1	2.2	0.5
Las Vegas	52	4.7	1.3	2.5	0.7
Milford	52	6.5	1	2.4	1
Overton	50	5.5	1.2	2.6	1
Pahrump	52	4.9	1.1	2.3	0.8
Pioche	52	3.9	0.6	6.2	0.6
Rachel	48	5	1.3	2.5	0.8
St. George	52	5.6	1	2.5	1
Tonopah	52	6.8	1.1	2.4	0.9
Mean MDC = 1.12 x 10^{-15} Ci/mL			Standard Deviation of Mean MDC = 0.15 x 10^{-15} Ci/mL		

Table 5.20 TLD Monitoring Results for Offsite Stations - 2000

		Daily Exposure (mR)			
Sampling Location	**Days**	**Minimum**	**Maximum**	**Mean**	**Total (mR) Exposure**
Alamo	370	0.13	0.23	0.19	71
Amargosa Center	370	0.17	0.21	0.19	71
Beatty	370	0.27	0.34	0.30	111
Boulder City	370	0.16	0.23	0.20	73
Caliente	287	0.22	0.24	0.22	82
Cedar City	372	0.15	0.19	0.17	63
Delta	372	0.18	0.22	0.20	75
Goldfield	370	0.17	0.29	0.23	83
Henderson	370	0.18	0.27	0.22	82
Indian Springs	370	0.14	0.22	0.18	66
Las Vegas	371	0.13	0.17	0.15	55
Milford	371	0.29	0.34	0.31	112
Overton	370	0.11	0.19	0.17	60
Pahrump	279	0.10	0.14	0.12	45
Pioche	377	0.18	0.22	0.20	72
Rachel	369	0.20	0.32	0.28	98
St. George	281	0.12	0.16	0.14	51
Tonopah	278	0.23	0.32	0.28	102
Sarcobatus Flats	370	0.24	0.33	0.29	106
Medlins Ranch	369	0.27	0.30	0.28	103

Table 5.21 Summary of Gamma Exposure Rates (µR/hr) as Measured by PIC - 2000

Sampling Location	Maximum	Minimum	Standard Deviation	Average	mR/Year
Alamo	13.4	11.9	0.40	12.2	107
Amargosa Center	13.6	9.5	1.29	12.1	107
Beatty	18.7	15.7	0.62	17.4	152
Boulder City	14.2	10.9	1.05	11.4	100
Caliente	17.3	13.1	1.00	14.2	125
Cedar City	11.1	9.1	0.49	9.7	86
Delta	14.4	11.0	0.57	11.6	102
Henderson	15.5	11.4	1.09	12.4	109
Goldfield	16.2	14.4	0.43	15.2	133
Indian Springs	13.4	9.8	0.55	10.3	91
Las Vegas	11.6	8.9	0.71	9.3	82
Medlins Ranch	17.0	15.1	0.50	15.5	137
Milford	18.8	16.0	0.62	17.0	150
Overton	11.3	8.5	0.70	9.2	81
Pahrump	8.8	7.9	0.29	8.0	71
Pioche	13.2	11.1	0.44	11.8	104
Rachel	16.2	14.0	0.49	15.1	133
St. George	9.2	6.2	0.74	7.7	68
Sarcobatus Flats	17.1	15.5	0.37	16.1	142
Tonopah	18.2	15.8	0.38	17.1	150

Table 5.22 Average Natural Background Radiation for Selected U.S. Cities (Excluding Radon)

City	Radiation (mrem/yr)
Denver, CO	164.6
Tampa, FL	63.7
Portland, OR	86.7
Los Angeles, CA	73.6
St. Louis, MO	87.9
Rochester, NY	88.1
Wheeling, WV	111.9
Richmond, VA	64.1
New Orleans, LA	63.7
Fort Worth, TX	68.7

Note: From http://www.wrcc.dri.edu/cemp/Radiation.html.

6.0 NONRADIOLOGICAL ENVIRONMENTAL PROGRAMS

The 2000 nonradiological monitoring program for the Nevada Test Site (NTS) included onsite sampling of various environmental media and substances for compliance with federal and state regulations or permits and for ecological studies. The Ecological Monitoring and Compliance (EMAC) program performed habitat mapping in northern NTS areas, characterized springs, monitored man-made water sources, conducted wild horse surveys, and prepared a biological monitoring plan for the Hazardous Materials Spill center (HSC). In 2000, nonradiological monitoring was performed for four series of test involving 24 chemicals that were at the HSC.

6.1 WATER SURVEILLANCE

SAFE DRINKING WATER ACT (SDWA)

Four public water system permits are maintained on the NTS (see Table 3.4). Until September 2000, three water hauling permits for potable water were also maintained. In September 2000, the U. S. Department of Energy National Nuclear Security Administration/Nevada Operations Office (NNSA/NV) only renewed two of those permits (see Table 3.4). All other water systems on the NTS are considered private water systems and are operated outside of the scope of state and federal regulation.

In 2000, water sampling was conducted for analysis of coliform bacteria, lead, copper, nitrates, fluoride, and radionulcides as required by the SDWA, state of Nevada regulations, and the NTS Contaminant Monitoring Waivers. Samples were collected from supply wells for nitrates, fluoride, and radionuclides and from taps within the drinking water distribution systems for coliform bacteria, lead and copper. All samples were collected in accordance with accepted practices, and the analyses were performed by state-approved laboratories. Approved analytical methods listed in Nevada Administrative Code (NAC) 445A (NAC 1996) and Title 40 Code of Federal Regulations (CFR) 141 were used.

Bacteriological Sampling

All water distribution systems were tested either monthly or quarterly for coliform bacteria, with the number of people being served determining the number of samples collected and the frequency (see Table 6.1). If coliform bacteria are present, confirmation samples are collected, and the source of contamination is determined by the water system operator. There were no incidents of positive coliform results in NTS distribution systems in 2000.

Samples from permitted water hauling trucks were analyzed monthly for coliform bacteria. One sample tested positive. The truck was rinsed and disinfected prior to resampling. The resampling showed no coliform bacteria. It was determined that lack of adequate flushing before sample collection caused the positive result.

Organic Compound Analysis

In accordance with the monitoring waivers issued in 1996, the NNSA/NV did not collect Volatile Organic Compound samples in 2000.

Metal Analysis

Samples were collected from taps in the Area 12 public water system (NY-4099-12C) in the third and fourth quarters and analyzed for lead and copper. All results were below the action level of 1.3 mg/L for copper. Lead results, however, exceeded the 0.015 mg/L action level for lead. The samples were collected from the only building in Area 12 that was regularly used during this period, the Miners' Change House (Building 12-43), and from a hose connection outside this building. Lead solder is the suspected to be the cause of the high action level for lead. The NNSA/NV is in the process of determining a remedy for this situation, but in the interim, the water is only being used for non-consumption purposes. Water for drinking is supplied from a lead-free source.

Reduced monitoring for lead and copper is in effect in two of the other water systems (NY-0360-12C and NY-4098-12NTNC), and the Area 1 system (NY-5024-12NTNC) no longer has any active service connections.

Other Inorganic Chemical Analysis

To comply with a 1991 variance to the Area 25 water system permit, fluoride samples are collected annually from the two wells in Area 25 (NY-4098-12NTNC) before July 31 to confirm that the fluoride concentration is less than four parts per million. Samples taken from Area 25 Wells J-12 and J-13 in the first quarter of 2000 confirmed that the fluoride concentrations were acceptable.

During the first quarter of 2000, samples were collected from each supply well and analyzed for nitrates. All results were within acceptable limits.

The results of inorganic analyses are shown in Table 6.2.

Inspections

The Nevada Bureau of Health Protection Services performed a formal inspection of the permitted water hauling trucks and reported no findings or discrepancies. The NNSA/NV resolved the one remaining finding from a 1999 sanitary survey, a pinhole leak in a storage tank. The leak was successfully repaired in 2000.

6.2 AIR SURVEILLANCE

Air quality monitoring for the criteria pollutants is not required for the NTS. With the exception of the air permit for the HSC, the permits issued by the state of Nevada do require opacity and material throughput measurements. The HSC received a waiver by the state from adhering to opacity limits, due to the nature of its operations. Nonradiological monitoring is required by the HSC's air permit, and was conducted for four series of tests conducted at the HSC in 2000.

MONITORING OF NTS OPERATIONS

Routine nonradiological environmental monitoring on the NTS in 2000 was limited to the HSC air permit requirements and asbestos sampling in conjunction with asbestos removal and renovation projects and in accordance with occupational safety and National Emission Standards for Hazardous Air Pollutants compliance.

The HSC was established in Frenchman Flat in Area 5 as a basic research tool for studying the dynamics of accidental releases of various hazardous materials and the effectiveness of mitigation procedures. In addition to state of Nevada air permit monitoring requirements, offsite monitoring of HSC tests may be required by the U.S. Environmental Protection Agency (EPA). Prior to each HSC test series, and, at other tests in the series depending on projected need, the documentation describing the tests are reviewed by the EPA to determine whether appropriate air sampling equipment should be deployed downwind of the test at the NTS boundary to measure chemical concentrations that may have reached the offsite area. During 2000, no monitoring was required.

6.3 ECOLOGICAL MONITORING

The ecological monitoring tasks conducted under the EMAC program in 2000 included habitat mapping, monitoring of special interest plants and wildlife, monitoring wetlands and wildlife water sources, and review of test plans for experiments conducted at the HSC to determine if biological monitoring was needed.

HABITAT MAPPING

Work was initiated in 1996 to map plant and wildlife habitats of the NTS. Over the last four years, Ecological Landform Units (ELUs) were identified in the field (Bechtel Nevada [BN] 1998) and vegetation data were collected within representative ELUs, analyzed to classify plant communities, and then converted to geographic data to produce a plant habitat map of the entire NTS (BN 1998). Also, geographic information system (GIS) databases of each mapped plant community and of historic and current wildlife data were developed for linkage with geographic maps of the NTS. Work in calendar year (CY) 2000 focused on summarizing and documenting all vegetation and wildlife data collected or archived. In CY 2000, the draft report Classification of Vegetation on the Nevada Test Site was completed and submitted to the NNSA/NV for review (Ostler *et al.*, 2000) . This report will be published and distributed in CY 2001.

The NTS plant habitat data and GIS coverages were provided in CY 2000 to government and state agencies including the U.S. Fish and Wildlife Service (USFWS), Nevada Natural Heritage Program, Desert Research Institute, state of Utah Department of Natural Resources, Utah State University, Pacific Northwest National Laboratory, University of Wyoming, and The Nature Conservancy. BN biologists assisted researchers from the U.S. Geological Survey Biological Services in accessing some of the NTS vegetation study plots sampled in the 1970s. Photographs and field data were taken at the study plots which indicated that significant changes to plant species and community composition had occurred in the past 30 years. Studies will be useful to document changes due to climatic shifts (e.g., global warming) and direct and indirect effects of nuclear testing.

Cost-effective remote-sensing techniques, which could be used to monitor changes in NTS shrubland alliances over time, continued to be evaluated in CY 2000 through cooperative research sponsored by the Strategic Environmental Research and Development Program (SERDP). The SERDP is jointly funded by the U.S. Department of Defense, DOE, and EPA. Aerial photographs taken at different altitudes over Frenchman Flat were analyzed with new software designed to estimate shrub cover and density, and the efficacy of the software was then evaluated. New IKONOS satellite images with 1-m^2 pixel size were also analyzed with the same software. Such technology is expected to be incorporated into long-term habitat monitoring of the NTS.

SENSITIVE SPECIES MONITORING

There are 26 species which occur on the NTS that are considered sensitive because they are either (1) candidates for listing under the Endangered Species Act (ESA), (2) considered species of concern by the USFWS, (3) protected by other federal acts, or (4) state-managed species of public interest. The goal of sensitive species monitoring is to ensure their continued presence on the NTS by protecting them from significant impacts due to actions of the NNSA/NV. A secondary goal is to gather sufficient information on these species' distribution and abundance on the NTS to determine if further protection under state or federal law is necessary.

SENSITIVE PLANTS

Thirteen sensitive plant species are known to occur on the NTS. The NNSA/NV has funded efforts to collect data on the status of these plants and produced documents reporting their occurrence, distribution, and susceptibility to threats on the NTS (Anderson, 1998; Blomquist *et al.*, 1995; Blomquist *et al.*, 1992). In CY 2000, a long-term adaptive monitoring plan for all sensitive plants on the NTS was developed. The plan was submitted to the NNSA/NV for review in September (BN 2000) and will be implemented in CY 2001. The plan identifies the parameters which will be measured and the various adaptive management actions which may be taken if significant threats to the plants are detected.

The number of sensitive plant populations included in the monitoring plan are shown in Table 6.3. Two sensitive species which occur near the southern border of the NTS (*Penstemon albomarginatus* [White-margined beardtongue] and *Penstemon fruticiformis* var. *amargosae* [Death Valley beardtongue]) are not listed in Table 6.3 and are not included in the monitoring plan. They would be monitored if new populations were found on the NTS.

Monitoring will consist of two activities: preactivity surveys at new project sites and periodic field monitoring of known sensitive plant locations. Preactivity surveys are conducted to assess the direct impacts of land disturbance, and periodic monitoring of plant locations will be conducted to assess other indirect impacts. Periodic field monitoring will involve visiting each known location in a single season at least once every five years for those species which have limited numbers (<10) of known locations (Table 6.3). For species with larger numbers of known locations, a sub-sample of five to ten locations will be monitored in a single season at least once every five years. For each species, the five to ten locations chosen to sample may not be the same from sampling period to sampling period, and some locations may never be routinely sampled. The intent is to sample locations where direct effects of NTS activities and other factors such as drought or grazing/predation can best be detected. If a single known plant population is found within a proposed project site, or is observed during periodic field monitoring to be significantly impacted by a disturbance, then site-specific management actions will be implemented.

WESTERN BURROWING OWL

The western burrowing owl (*Speotyto cunicularia*) is a species of concern which breeds on the NTS. This owl occurs in all three eco-regions of the NTS: the Great Basin Desert, Transition Zone, and the Mojave Desert. It occupies the burrows of predators (e.g., coyote, kit fox, badger) and desert tortoises, as well as man-made structures such as buried pipes. Collection of baseline data continued in CY 2000 to identify their distribution and abundance on the NTS.

Five new burrow sites were found this year, bringing the total number of known burrow sites to 69. Of the 69 known sites, 44 are in disturbed habitat (e.g., burrow is located in a roadside berm or a metal culvert) and 25 are in undisturbed habitat (Figure 6.1).

Monthly monitoring of 59 of the 69 sites was conducted from October 1999 through September 2000, and the following conclusions may be drawn from the monitoring data:

- Fall migration of some owls off of the NTS probably occurs from October through January.

- Some owls reside year round in the Transition and Great Basin eco-regions.

- Owls are probably moving through the NTS on their northward spring migration from mid-March to early April.

An active infrared beam and camera system was used as a passive data collection method to record the presence of breeding owls and their young at selected burrows. It is important to know when burrowing owls breed and when young fledglings leave the nest. This information will help ensure that burrows are avoided and owls are unharmed during construction activities for new projects on the NTS. It is also important to document trends in owl populations over time to determine if this species is being affected by activities of the NNSA/NV. A good parameter to measure owl population trends is the annual number of breeding pairs.

Twenty-four burrow sites were monitored using the camera system between February and August. Forty-five young owls were detected from eight breeding pairs (Table 6.4). Thirty-four of the 45 young were from burrows in the Transition eco-region of the NTS. The largest number of young owls observed at a single nest was eight. The number of young detected this year nearly doubled the number detected last year (24). An average of 5.6 young per breeding pair was observed this year. Last year an average of 3.4 young per breeding pair was observed (BN 1998). The breeding period in CY 2000 appeared to be from early March through early September.

To develop reasonable mitigation recommendations for land-disturbing projects in burrowing owl habitat, it is important to know the level of disturbance owls tolerate without causing nest abandonment. Two methods were used this year to begin to determine this disturbance tolerance. One method involved setting traffic counters near active burrow nest sites and recording the number of vehicle passes and the distance from the nest burrow to the road. The second was measuring the distance at which owls flushed from observers as they approached the owl by foot and in a vehicle. Preliminary results show that owls can breed successfully with several vehicles per day passing within 14 to 165 meters (m) of a nest burrow. No correlation is evident between the number of vehicles per day or distance to road and the number of young observed. The average flushing distance while an observer was approaching a burrow on foot was 34 m (range 3 m to 80 m; [n=32]). The average flushing distance while an observer was approaching a burrow in a vehicle was 48 m (range 5 m to 135 m; [n=9]). Based on these data, it may be a reasonable mitigation recommendation for new construction projects to avoid active owl nests during the breeding season (March through September) by a minimum of 50 m.

BAT SPECIES OF CONCERN

To date, a total of 14 bat species has been documented on the NTS, of which 7 are species of concern. They are the Townsend's big-eared bat (*Corynorhinus townsendii*), spotted bat (*Euderma maculatum*), small-footed myotis (*Myotis ciliolabrum*), long-eared myotis (*Myotis evotis*), fringed myotis (*Myotis thysanodes*), the long-legged myotis (*Myotis volans*), and the big free-tailed bat (*Nyctinomops macrotis*).

Monitoring to identify the distribution of bat species of concern on the NTS continued this year. Seventy bats representing four species of concern were captured in mist-nets at water sources in the Great Basin Desert eco-region. No bat species of concern were captured in the other two eco-regions of the NTS (Mojave Desert, Transition Zone).

Mines and tunnels are important or even critical habitats for some bat species. These man-made excavations can be used as day and night roosts, maternity colonies, and hibernacula. To determine which NTS mines and tunnels are being used by which bat species, the Anabat II device (Titley Electronics, Ballina, Australia) was used in 1999 and 2000. This device records and analyzes ultrasonic bat vocalizations and it was set up outside selected mines/tunnels just prior to sunset. In 1999, the old Climax mine adit, the Mine Mountain adit and shafts, A Tunnel, B Tunnel, and N Tunnel complex were sampled. Recorded calls from these sites were analyzed in 2000. Four species of concern were found to be using the NTS tunnels. The 1999 recorded calls were identified as those of the small-footed myotis (A Tunnel), the long-eared myotis (A Tunnel), the fringed myotis (B Tunnel), and the long-legged myotis (B and N tunnels). The sites sampled in 2000 included the Wahmonie mine shaft, T Tunnel, E Tunnel, IJK Tunnel complex, A Tunnel, and B Tunnel. This year, bat calls were recorded at all of the mine/tunnel sites sampled except E Tunnel. Analysis of the recorded calls to identify species for 2000 is not yet completed.

WILD HORSES

Wild horses (*Equus caballus*) occur on the NTS, and ongoing monitoring of this species was conducted in 2000. Wild horses are protected on public lands under the Wild Free-Roaming Horse and Burro Act of 1971. This act calls for the management and protection of wild horses and burros in a manner that is designed to achieve and maintain a thriving natural ecological balance. Although the NTS is on land withdrawn from public use, the NNSA/NV is committed to this same management goal on the NTS. In 1997, the NNSA/NV signed a Five-Party Cooperative Agreement with Nellis Air Force Range (NAFR), USFWS, U.S. Bureau of Land Management, and the state of Nevada Clearinghouse. The goal of the agreement is to enhance management of the natural resources within ecosystems on the NAFR, the NTS, and the Desert National Wildlife Range. This agreement facilitates an ecosystem-based approach in the management of free-roaming animals with large home ranges, such as wild horses. BN conducts an annual horse census on the NTS. The NTS horse population has not increased in size over time as on the NAFR, and it appears to be isolated from the NAFR population. In the past five years, a decline in horse numbers on the NTS has been observed.

In 2000, BN biologists performed four tasks related to horse monitoring:

- Annual horse abundance was estimated to monitor population stability.
- Horse signs were recorded along selected roads to better define the geographic range of horses on the NTS.
- Selected natural and man-made water sources were visited in the summer to determine their influence on horse distribution and movements and to determine the impact horses are having on NTS wetlands.
- A monitoring plan for wild horses on the NTS was completed.

Since 1995, the feral horse population has declined 31 percent, from 54 to 37 horses (these counts exclude foals) (Table 6.5). Of the 23 horses which have been classified as missing since 1995, 12 were adult males, 9 were adult females, and 2 were yearlings of unknown sex. No foals observed in 1995 through 1998 survived to yearlings. The cause of the population decline appears to be (1) low recruitment due to very poor foal survival and (2) moderate adult mortality.

Horse sign data collected during the road surveys and surveys at natural and man-made water sources indicate that the 2000 NTS horse range includes Kawich Canyon, Gold Meadows, Yucca Flat, southwest foothills of the Eleana Range, and southeast Pahute Mesa (Figure 6.2).

At present, the NTS horse herd appears to consist of two groups, one larger group (about 24 horses) that spends summers west of the Eleana Range and one smaller group (12-13 horses) that spends summers east of the Eleana Range on Yucca Flat. These groups of horses probably intermix during the winter but the exact mixing areas are unknown. More information on winter range of horses needs to be developed in the future. Overall, the annual horse range appears to have changed very little from the previous year. However, the small group of 12-13 horses on Yucca Flat appear to be using a smaller forage area than in previous years. This is possibly due to the reduced number of water resources on northern Yucca Flat which probably limits the extent of their grazing range to the north.

The NTS horse population is dependent on several natural and man-made water sources in Areas 18, 12, and 30 (Figure 6.2) during different seasons. Wildhorse and Little Wildhorse seeps are important winter-spring water sources. Two natural water sources (Captain Jack Spring and Gold Meadows Spring) and one man-made pond (Camp 17 Pond) were used by horses in the summer, as in past years. Overall, Captain Jack Spring, Gold Meadows Spring, and Camp 17 Pond were the most important water sources for horses based on the presence and quantity of horse sign and trampled and grazed vegetation.

There are presently six man-made water sources within or on the edge of the annual horse range and none of them were used by horses in 2000. Only two of these sources are permanent (contain water year round). These are the E Tunnel Containment Ponds and the Area 12 Sewage Ponds. No horse sign have ever been found at these permanent man-made water sources.

The horse monitoring program was evaluated this year for its ability to determine if the NTS Resource Management Plan goals for horse protection are being met (DOE 1998a). As a result, a monitoring plan was developed and submitted to the NNSA/NV for review in September. The plan identifies desired minimum and maximum sizes of the NTS horse population and identifies possible adaptive management actions which may be taken if these sizes are reached. If the horse population continues to decline, the plan calls for studies to be developed and implemented to determine the cause(s). Because horses are not native to the NTS, there are currently no proposed management actions to increase the herd size.

RAPTORS

Several raptors occur and breed on the NTS which are not protected under the ESA and are not species of concern. They are, however, protected by the federal government under the Migratory Bird Treaty Act and by the state of Nevada. Raptors include all vultures, hawks, kites, eagles, ospreys, falcons, and owls. Because these birds occupy high trophic levels of the food chain, they are regarded as sensitive indicators of ecosystem stability and health. There are eight raptors (Table 6.6) which are known to breed on the NTS (Greger and Romney, 1994); however, only a few records exist, of breeding raptors on the NTS or of their reproductive

success, egg incubation periods, and fledging times (time when young leave the nest). Surveys to locate raptor nests and the number of breeding pairs of raptors began on the NTS in 1998 and were continued in 2000.

From April through July 2000, the following regions were surveyed: Yucca Flat, Horse Wash, Oak Spring Butte, Buckboard Mesa, Rainier Mesa, lower Stockade Wash, North Shoshone Mountain, and the Tippipah Spring area. Also, nineteen known nests were revisited to check for reproduction.

Four new red-tailed hawk nests were detected during ground searches (Figure 6.3). Six active raptor nests were detected this year. All six were those of red-tailed hawks. They included a microwave tower nest, two power line pole nests, a willow tree nest, a Joshua tree nest, and a cliff nest. The number of red-tailed hawk active nests and nestlings observed this year was more than last year. The total number of nestlings and number of active nests (Table 6.7) was lower in both 1999 and 2000 (dry years) compared to 1998 (a wet year).

Although monitoring has only occurred for three years, it appears that the reuse of existing nests is not common on the NTS. Only 1 of 10 (10 percent) raptor nests known in 1998 were reused in 1999, and only 2 of 15 (13 percent) raptor nests known in 1999 were reused in 2000.

Few raptor mortalities have been recorded at the NTS. Wildlife observations, made opportunistically by BN biologists and other NTS workers, are maintained by BN biologists in a computerized database. Accounts of injured and dead animals are also usually reported to BN biologists and are stored in the same database. Over the last 10 years, from 1990-2000, 16 incidents of dead raptors have been recorded on the NTS. The known causes of death include seven roadkills, two electrocutions, two predator kills, and two drownings (Table 6.8).

MONITORING NATURAL WATER SOURCES

Natural wetlands and man-made water sources on the NTS provide unique habitats for mesic and aquatic plants and animals and attract a variety of other wildlife. Natural NTS wetlands may qualify as jurisdictional wetlands under the Clean Water Act (CWA). Characterization of these mesic habitats to determine their status under the CWA and periodic monitoring of their hydrologic and biotic parameters are components of the Ecological Monitoring program which was started in 1997. Periodic wetlands monitoring may help identify annual fluctuations in measured parameters that are natural and unrelated to activities of the NNSA/NV. Also, if a spring classified as a jurisdictional wetland was unavoidably impacted by a NNSA/NV project, mitigation for the loss of wetland habitat would be required under the CWA. Under these circumstances, wetland hydrology, habitat quality, and wildlife usage data collected at the impacted spring over several previous years can help to develop a viable mitigation plan and demonstrate successful wetland mitigation.

Monitoring of selected NTS wetlands was continued this year to characterize seasonal trends in physical and biological parameters. Fourteen wetlands were visited at least once to record the presence/absence of land disturbance, water flow rates, and surface area of standing water (Table 6.9). Observations at Pahute Mesa Pond in the spring confirmed that field indicators were present for vegetation, hydrology, and soils, and it was concluded that the lower one-half of the pond was considered to have jurisdictional status as a wetland. No jurisdictional or nonjurisdictional wetlands on the NTS were disturbed during 2000 and no U.S. Army Corps of Engineers 404 Permit was required.

Wildlife and wildlife sign observed during visits to NTS wetlands were recorded. Four species of mammals and 17 species of birds were detected . The most widely distributed mammal species were coyote and mule deer, observed at 12 and 11 of the 14 sites, respectively. Horses and mountain lion were the other mammals observed. Mourning dove, chukar, and Gambel's quail were the most widely distributed bird species observed and were also the most abundant.

MONITORING MAN-MADE WATER SOURCES

Man-made excavations constructed to contain water occur throughout the NTS. Like natural water sources, they too can affect the movement patterns of some species (e.g., wild horses). However, they can also cause accidental wildlife mortalities from entrapment and drowning if not properly constructed or maintained. Quarterly monitoring of man-made water sources was conducted in 2000. These sources, located throughout the NTS, included 35 plastic-lined sumps, 39 sewage treatment ponds, 13 unlined well ponds, and 4 radioactive containment ponds. They are monitored to assess their use by wildlife and to develop and implement mitigation measures to make them safer for use by wildlife. Mitigation measures, required under the Mitigation Action Plan for the Final Environmental Impact Statement (DOE 1996c), include placing flag lines over contaminated water sources to repel birds, or fencing or covering them. Quarterly monitoring ensures that all flag lines, fencing, or covers are checked for their integrity and repaired when needed.

Man-made water sources were visited during four quarterly sampling periods; November, February, May and August 2000 . Use of unlined sumps and ponds by waterfowl (ducks, shorebirds), passerine birds (ravens, horned larks, house finches), and mammals such as coyotes and deer was common. The fences installed around the plastic-lined sumps do not exclude coyotes or deer, as their tracks were observed commonly inside many of the fences. Birds were observed much less at the plastic-lined sumps compared to the unlined ponds.

No dead animals were recorded in any plastic sumps during fiscal year (FY) 2000. A sediment mound was constructed in Sump # 3 at ER-20-6 in 2000 to prevent deer drownings. This sediment ramp appears to be working well as deer sign have been recorded at this site, yet no additional deer drownings have occurred. No functional flaglines have been present at any plastic-lined ponds on the NTS for the last three years. No mortality of birds have occurred in these sumps, however, since the flaglines have been absent. This indicates that flaglines presently are not necessary to prevent bird mortality. Flagline conditions will not be monitored in the future unless conditions require their reinstallation.

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Table 6.1 Frequency of Coliform Bacteria Monitoring for NTS Public Water Systems

Public Water System	Monitoring Frequency
NY-0360-12C	Monthly - 3 Samples
NY-4098-12NTNC	Quarterly - 1 Sample
NY-4099-12C	Monthly - 1 Sample
NY-5024-12NTNC	Quarterly - 1 Sample
NY-0835-12H	Monthly - 1 Sample
NY-0836-12H	Monthly - 1 Sample

Table 6.2 Analyses of Well Water Samples - 2000

Water System/Well	Nitrates (MCL[c] 10 ppm[a])	Fluoride (MCL 4 ppm)	Lead (action level .015 ppm)
NY-0360-12C			
Army Well	[b]		
Well 5B	2.8		
Well 5C	1.8		
Well 4	3.5		
Well 4A	4.0		
Well C-1	[b]		
NY-4098-12NCN			
Well J-12	2.1	1.7	
Well J-13	2.2	2.0	
NY-4099-12C			.026
Well 8	1.3		
NY-5024-12NCN			
Well UE16d	[b]		

(a) Parts per million.
(b) Not detected.
(c) Maximum contaminant level.

Table 6.3 Number of known Locations of Sensitive Plants on the NTS

Plant Species	Number of Known Locations
Arctomecon merriamii	17
Astragalus beatleyae	33
Astragalus funereus	9
Astragalus oophorus var. *clokeyanus*	22
Camissonia megalantha	11
Cymopterus ripleyi var. *saniculoides*	18
Frasera pahutensis	9
Galium hilendiae ssp. *kingstonense*	5
Penstemon pahutensis	88
Phacelia beatleyae	41
Phacelia parishii	32

Table 6.4 Summary of Burrow use by Pairs of Owls on the NTS - FY 2000

Eco-region	Sites Surveyed	Burrows With Non-breeding Pairs	Burrows With Breeding Pairs	Juvenile Owls
Mojave Desert	7	1	1	3
Transition	13	2	6	34 (4--7/burrow)
Great Basin Desert	4	0	1	8
Totals	**24**	**3**	**8**	**45**

Table 6.5 Number of Horse Observed on the NTS by Age Class, Gender, and Year Since 1995

Age Class	Number of Horses Observed											
	1995		1996		1997		1998		1999		2000	
Foals	1		1		3		8		5		11	
Yearlings	3		0		0		0		0		4	
Adults	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
2 Year Olds	0	0	0	1	0	0	0	0	0	0	(2)	0
3 Year Olds	0	0	0	0	0	1	0	0	0	0	0	0
> 3 Years Old	22	29	21	24	19	20	16	21	11	20	12	21
Total	**54**		**46**		**40**		**37**		**31**		**37**	

Note: (M=male; F=female)

Table 6.6 Raptor Species that Occur and Breed on the NTS

Raptor Species	Common Name
Aquila chrysaetos	Golden eagle
Asio otus	Long-eared owl
Buteo jamaicensis	Red-tailed hawk
Buteo swainsoni	Swainson's hawk
Falco mexicanus	Prairie falcon
Falco sparverius	American kestrel
Speotyto cuniculaia	Western burrowing owl
Tyto alba	Barn owl

Table 6.7 Summary of Raptor Reproduction Observed on the NTS

	Number of Active Nests			Number of Young Observed		
Species	FY 1998	FY 1999	FY 2000	FY 1998	FY 1999	FY 2000
Golden eagle	1	2	0	1	2	0
Prairie falcon	1	0	0	5	0	0
Red-tailed hawk	7	4	6	10	2	10
Swainson's	1	0	0	2	0	0
Totals	**10**	**6**	**6**	**18**	**4**	**10**

Table 6.8 Summary of NTS Raptor Mortality Records from 1990-2000

Species	**Roadkill**	**Electrocution**	**Suspected Drowning**	**Predation**	**Unknown**	**Totals**
American kestrel				1	1	**2**
Barn owl	1				1	**2**
Golden eagle	1	1				**2**
Great-horned owl	3					**3**
Prairie falcon				1		**1**
Red-tailed hawk	2	1	1			**4**
Turkey vulture					1	**1**
Western burrowing owl			1			**1**
Totals	**7**	**2**	**2**	**2**	**3**	**16**

Table 6.9 Seasonal Data from Selected Natural Water Sources on the NTS Collected During FY 2000

Water Source	**Date**	**Surface Area of Water (m^2)[a]**	**Surface Flow Rate (L/Min)[b]**	**Disturbance at Spring**
Cane Spring	5/10	15	2.4	None
Cane Spring	8/31	9	2.4	None
Captain Jack Spring	5/3	40	2	None
Captain Jack Spring	7/27	40	1.1	Horse grazing and trampling
Gold Meadows Spring	5/2	600	0	Horse grazing and trampling
Gold Meadows Spring	8/15	0	0	Horse grazing and trampling
Little Wildhorse Seep	4/27	18	NM	Horse grazing and trampling
Little Wildhorse Seep	7/20	0	0	None
Pahute Mesa Pond	6/13	0	0	None
Reitmann Seep	5/24	0.04	0	None
Reitmann Seep	9/14	0.03	0	None
Tippipah Spring	5/4	440	3.6	None
Tippipah Spring	8/31	290	1.2	None
Topopah Spring	8/10	1.5	0.5	None
Wahmonie Seep No. 1	6/26	0	0	None
Wahmonie Seep No. 2	6/26	0	0	None
Wahmonie Seep No. 3	6/26	0	0	None
Wahmonie Seep No. 4	6/26	2	NM	None
Whiterock Spring	5/17	70	2.7	None
Whiterock Spring	9/13	60	3	None
Wildhorse Seep	4/27	45	NM	Horse grazing and trampling
Wildhorse Seep	7/20	0	0	None

Table 6.10 NTS Drinking Water Permits - 2000

Permit No.	Area(s)	Expiration Date	Reporting Required
NY-360-12C	Area 5, 6, 22, 23	09/30/2001	[a]
NY-4098-12NTNC	Area 25	09/30/2001	[a]
NY-4099-12C	Area 2 & 12	09/30/2001	[a]
NY-5024-12NTNC	Area 1	09/30/2001	[a]
NY-835-12H	Sitewide - Truck	09/30/2001	[a]
NY-836-12H	Sitewide - Truck	09/30/2001	[a]

(a) Monitoring is reported within 10 days after each monitoring period.

U12N Overview of All Ponds from the Top of Muck Pile (March 13, 1989)

7.0 SITE HYDROLOGY

The hydrologic character of the Nevada Test Site (NTS) and vicinity reflects the region's arid climatic conditions and complex geology (D'Agnese *et al*., 1997). The hydrology of the NTS has been extensively studied for over 40 years (U. S. Department of Energy [DOE] 1996c), and numerous scientific reports and large databases are available. The following sections present an overview of the hydrologic setting of the NTS and vicinity, including summary descriptions of surface water and groundwater, hydrogeologic framework, and finally a summary of the hydrogeology for each of the former underground test areas on the NTS.

7.1 SURFACE WATER

The NTS is located within the Great Basin, a closed hydrographic province which comprises several closed hydrographic basins (Figure 7.1). The closed hydrographic basins of the NTS (most notably Yucca and Frenchman Flats) are subbasins of the Great Basin. Streams in the region are ephemeral, flowing only in response to precipitation events or snowmelt. Runoff is conveyed through normally dry washes toward the lowest areas of the closed hydrographic subbasins, and collects on playas. Two playas (seasonally dry lakes) occur on the NTS: Frenchman Lake and Yucca Lake, which lie in Frenchman and Yucca Flats, respectively. While water may stand on the playas for a few weeks before evaporating, the playas are dry most of the year. Surface water may leave the NTS in only a few places, such as Fortymile Canyon in the southwestern NTS.

Springs that emanate from local perched groundwater systems are the only natural sources of perennial surface water in the region. There are 20 known springs or seeps on the NTS (Hansen *et al*., 1997) (Figure 7.2). Spring discharge rates are low, ranging from 0.014 to 2.2 liters/sec (0.22 to 35 gal/min) (International Technology [IT] 1997). Most water discharged from springs travels only a short distance from the source before evaporating or infiltrating into the ground. The springs are important sources of water for wildlife, but they are too small to be of use as a public water supply source.

Other surface waters on the NTS include man-made impoundments constructed at several locations throughout the NTS to support various operations. These are numerous, and include open industrial reservoirs, containment ponds, and sewage lagoons (DOE 1998a). Surface water is not a source of drinking water on the NTS.

7.2 GROUNDWATER

The NTS is located within the Death Valley regional groundwater flow system, one of the major hydrologic subdivisions of the southern Great Basin (Waddell *et al*., 1984; Laczniak *et al*., 1996). Groundwater in southern Nevada is conveyed within several flow-system subbasins within the Death Valley regional flow system (a subbasin is defined as the area that contributes water to a major surface discharge area [Laczniak, *et al*., 1996]). Three principal groundwater subbasins, named for their down-gradient discharge areas, have been identified within the NTS region: the Ash Meadows, Oasis Valley, and Alkali Flat-Furnace Creek Ranch subbasins (Waddell *et al*., 1984) (Figure 7.3).

State Boundary
NTS Operational Areas
Nellis Air Force Range
NTS Boundary

The groundwater-bearing rocks at the NTS have been classified into several hydrogeologic units, of which the most important is the lower carbonate aquifer, a thick sequence of Paleozoic carbonate rock. This unit extends throughout the subsurface of central and southeastern Nevada, and is considered to be a regional aquifer (Winograd and Thordarson 1975; Laczniak, *et al*., 1996; IT 1996a). Various volcanic and alluvial aquifers are also locally important as water sources.

The depth to groundwater in wells at the NTS varies from about 210 m (690 ft) below the land surface under the Frenchman Flat playa in the southeastern NTS, to more than 610 m (2,000 ft) below the land surface in the northwestern NTS, beneath Pahute Mesa (IT 1996b; Reiner et al., 1995). Perched groundwater (isolated lenses of water lying above the regional groundwater level) occurs locally throughout the NTS, mainly within the volcanic rocks.

Recharge areas for the Death Valley groundwater system are the higher mountain ranges of central and southern Nevada, where there can be significant precipitation and snowmelt. Groundwater flow is generally from these upland areas to natural discharge areas in the south and southwest. Groundwater at the NTS is also derived from underflow from basins up-gradient of the area (Harrill *et al*., 1988). The direction of groundwater flow may locally be influenced by structure, rock type, or other geologic conditions. Based on existing water-level data (Reiner et al., 1995; IT 1996b; DOE 1998a) and flow models (IT 1996a; D'Agnese *et al*., 1997) the general groundwater flow direction within major water-bearing units beneath the NTS is to the south and southwest (Figure 7.3).

Most of the natural discharge from the Death Valley flow system is via transpiration by plants or evaporation from soil and playas in the Amargosa Desert and Death Valley. Groundwater discharge at the NTS is minor, consisting of small springs which drain perched water lenses and artificial discharge at a limited number of water supply wells.

Groundwater is the only local source of potable water on the NTS. The ten potable water wells that make up the NTS water system and supply wells for the various water systems in the area (town of Beatty, small mines, and local ranches) produce water for human and industrial use from the carbonate, volcanic, and alluvial aquifers. Water chemistry varies from a sodium-potassium-bicarbonate type to a calcium-magnesium-carbonate type, depending on the mineralogical composition of the aquifer source. Groundwater quality within aquifers of the NTS is generally acceptable for drinking water and industrial and agricultural uses (Chapman 1994), and meets the U.S. Environmental Protection Agency(EPA) drinking Water Standards (Chapman and Lyles 1993; Rose *et al*., 1997; BN 2000d).

7.3 HYDROLOGIC MODELING

The information in this section was compiled from various sources, as referenced throughout the discussion. However, the basic approach to these discussions is based on that taken to produce groundwater models for the various former test areas at the NTS for the Underground Test Area (UGTA) Program.

The Environmental Restoration Division of the National Nuclear Security Administration, Nevada Operation Office (NNSA/NV) initiated the UGTA project to study the effects of past underground nuclear testing in shafts and tunnels on groundwater at the NTS and surrounding areas. The multi-disciplinary UGTA investigation focuses on the geology and hydrology of the NTS to determine how contaminants are transported by groundwater flow. A regional three-dimensional computer groundwater model (IT 1996a; 1997) has already been developed to identify any immediate risk and to provide a basis for developing more detailed models of specific NTS test areas (designated as individual Corrective Action Units [CAUs]). The regional model constituted

Phase I of the UGTA project. The CAU-specific models, of which up to four are planned (geographically covering each of the six former NTS testing areas), comprise Phase II. To date one model has been built: Frenchman Flat (IT 1998). The Yucca Flat models are in progress. The results of the UGTA modeling project will be used to refine a monitoring network to ensure public health and safety.

Other hydrogeologic models for the area include those developed for the Yucca Mountain Program (YMP) (YMP 1998; Civilian Radioactive Waste Management System Management and Operating Contractor 1997) and the Death Valley regional groundwater flow system (D'Agnese *et al*., 1997). There are also site-specific models for the Radioactive Waste Management Sites (RWMSs) in Frenchman Flat, Area 5 (Shott *et al*., 1998) and Yucca Flat, Area 3 (BN 1997).

7.4 HYDROGEOLOGIC FRAMEWORK FOR THE NTS AND VICINITY

When the need for testing nuclear devices underground was recognized in the 1950s, among the first concerns was the effect testing would have on the groundwater of the area. One of the earliest nuclear tests conducted below the groundwater table (BILBY 1963) was designed in part to study explosion effects on groundwater and the movement in groundwater of radioactive byproducts from the explosion. Since that time, additional studies at various scales have been conducted to aid in the understanding of groundwater flow at the NTS. The current understanding of the regional groundwater flow at the NTS in derived from work by Winograd and Thordarson (1975), which was summarized and updated by Laczniak *et al*. (1996), and has further been developed by the UGTA hydrogeologic modeling team (IT 1996c, 1998b; Drellack and Prothro 1997; BN 2001a).

Winograd and Thordarson (1975) established a hydrogeologic framework, incorporating the work of Blankennagel and Weir (1973) who defined the first hydrogeologic units to address the complex hydraulic properties of volcanic rocks. Hydrogeologic units (HGUs) are used to categorize lithologic units according to their ability to transmit groundwater, which is mainly a function of their primary lithologic properties, degree of fracturing, and secondary mineral alteration. Hydrostratigraphic units (HSUs) for the NTS volcanic rocks were first defined during the UGTA modeling initiative (IT 1996a). HSUs are groupings of contiguous stratigraphic units that have a particular hydrogeologic character, such as aquifer (unit through which water moves readily) or confining unit (unit that generally is impermeable to water movement) (see Seaber [1988] for a discussion of hydrostratigraphy). The concept of HSUs is very useful in volcanic terrains where stratigraphic units can vary greatly in hydrologic character both laterally and vertically.

The rocks of the NTS have been classified for hydrologic modeling using this two-level classification scheme, in which HGUs are grouped to form HSUs (IT 1996a). An HSU may consist of several HGUs but is defined so that a single general type of HGU dominates (for example, mostly welded-tuff and vitric-tuff aquifers or mostly tuff confining units).

The hydrogeologic framework used for most groundwater flow and contaminant transport models for UGTA and other NTS programs are built on the work of Blankennagle and Weir (1973), Winograd and Thordarson (1975), and Laczniak *et al*., (1996). New units and additional detail have been added to the basic framework definition, but the systems developed by these early workers remain the best way to understand the groundwater of the NTS region. The following paragraphs describe the current understanding of the hydrogeologic framework of the NTS, first addressing HGUs, then describing the main HSUs.

HYDROGEOLOGIC UNITS OF THE NTS AREA

All the rocks of the NTS and vicinity can be classified as one of nine hydrogeologic units, which include the alluvial aquifer, four volcanic hydrogeologic units, two intrusive units, and two hydrogeologic units that represent the pre-Tertiary rocks (Table 7.1).

The deposits of alluvium (alluvial aquifer) fill the main basins of the NTS, and generally consist of a loosely consolidated mixture of boulders, gravel, and sand derived from volcanic and Paleozoic sedimentary rocks (Slate *et al*., 1999). The volcanic rocks of the NTS and vicinity can be categorized into four hydrogeologic units based on primary lithologic properties, degree of fracturing, and secondary mineral alteration. In general, the altered (typically zeolitized, or, hydrothermally altered near caldera margins) volcanic rocks act as confining units (tuff confining unit), and the unaltered rocks form aquifers. The volcanic aquifer units can be further divided into welded-tuff aquifers or vitric-tuff aquifers (depending upon the degree of welding) and lava-flow aquifers. The denser rocks (welded ash-flow tuffs and lava flows) tend to fracture more readily, and therefore have relatively high permeability (Blankennagel and Weir, 1973; Winograd and Thordarson 1975; Laczniak *et al*., 1996; IT 1997,1996c; Prothro and Drellack 1997).

An additional igneous HGU, the intercaldera intrusive confining unit (IICU), was defined for the Pahute Mesa hydrogeologic model (BN 2001a). Conceptually, an IICU underlies each of the calderas of the southwest Nevada volcanic field (SWNVF), and though no drill holes penetrate theses rocks, it is presume these bodies range from highly altered, highly injected/intruded country rock to granite. The IICU is considered to behave as a confining unit due to low primary porosity and low permeability, and because most fractures are probably filled with secondary minerals.

The pre-Tertiary sedimentary rocks at the NTS and vicinity are also categorized as aquifer or confining unit HGUs based on lithology. The silicic clastic rocks (quartzites, siltstones, shales) tend to be aquitards or confining units, while the carbonates (limestone and dolomite) tend to be aquifers (Winograd and Thordarson 1975; Laczniak *et al*., 1996). The granite confining unit (GCU) is considered to behave as a confining unit due to low primary porosity, low permeability, and because most fractures are probably filled with secondary minerals.

HYDROSTRATIGRAPHIC UNITS OF THE NTS AREA

The rocks at the NTS and vicinity are grouped into roughly sixty HSUs. The more important and widespread HSUs in the area are discussed separately in this section. Additional information regarding more restricted HSUs is presented in Section 7.5.

Lower Clastic Confining Unit (LCCU)

The Proterozoic to Middle-Cambrian rocks are largely quartzite and silica-cemented siltstone. Although these rocks are brittle and commonly fractured, secondary mineralization seems to have greatly reduced formation permeability (Winograd and Thordarson 1975). These units make up the LCCU, which is considered to be the regional hydrologic basement (IT, 1996a). The LCCU is interpreted to underlie the entire region except at the calderas. Where it is in a structurally high position, the LCCU may act as a barrier to deep regional groundwater flow.

Lower Carbonate Aquifer (LCA)

The LCA consists of thick sequences of Middle Cambrian through Upper Devonian carbonate rocks. This HSU serves as the regional aquifer for most of southern Nevada, and locally may be as thick as 5,000 m (16,400 ft) (Cole 1997; Cole and Cashman 1999). The LCA is present under most of the area except where the LCCU is structurally high and at the calderas.

Transmissivities of these rocks differ from place to place, apparently reflecting the observed differences in fracture and fault densities and characteristics (Winograd and Thordarson, 1975).

Upper Clastic Confining Unit (UCCU)

Upper Devonian and Mississippian silicic clastic rocks in the NTS vicinity are assigned to the Eleana Formation and the Chainman Shale (Cashman and Trexler 1991; Trexler et al., 1996). Both formations are grouped into the UCCU. At the NTS this HSU is found mainly within a north-south band along the western portion of Yucca Flat. It is a significant confining unit, and in many places forms the footwall of the Belted Range and Control Point (CP) thrust faults.

Lower Carbonate Aquifer, Upper Thrust Plate (LCA3)

Cambrian through Devonian, mostly carbonate, rocks that occur in the hanging wall of the Belted Range and CP thrust faults are designated as LCA3. These rocks are equivalent stratigraphically to the LCA, but are structurally separated from the LCA by the Belted Range thrust fault. The LCA3 is patchily distributed as remnant thrust blocks, particularly along the western and southern sides of Yucca Flat (at Mine Mountain and the CP Hills), at Calico Hills, and at Bare Mountain.

Mesozoic Granite Confining Unit (MGCU)

The Mesozoic era is represented at the NTS only by intrusive igneous rocks. Cretaceous-age granitic rocks are exposed at two locations: in northern Yucca Flat area, at the Climax stock; and the Gold Meadows stock, which lies 12.9 km (8 mi) west of the Climax stock, just north of Rainier Mesa (Snyder 1977; Bath *et al.*, 1983) (Figure 7.4). The two are probably related in both source and time and, may be connected at depth (Jachens 1999). Because of its low intergranular porosity and permeability, plus the lack of inter-connecting fractures (Walker 1962) the MGCU is considered a confining unit. The Climax and Gold Meadows intrusives are grouped into the MGCU HSU.

Tertiary and Quaternary Hydrostratigraphic Units

Tertiary- and Quaternary-age strata at the NTS are organized into dozens of HSUs. Nearly all are of volcanic origin, except the alluvial aquifer, which is the uppermost HSU. These rocks are important because (1) most of the underground nuclear tests at the NTS were conducted in these units, (2) they constitute a large percentage of the rocks in the area, and (3) they are inherently complex and heterogeneous. As pointed out in Section 7.4, the volcanic rocks are divided into aquifer or confining unit according to lithology and secondary alteration.

More discussion of these HSUs is provided in Section 7.5 where the hydrogeology of each underground test area at the NTS is addressed. Detailed information can be found in the documentation packages for the UGTA CAU-scale hydrogeologic models (IT 1996a, 1998; Gonzales and Drellack 1999; BN 2001a).

Alluvial Aquifer (AA)

The alluvium throughout most of the NTS is a loosely consolidated mixture of detritus derived from silicic volcanic and Paleozoic sedimentary rocks, ranging in particle size from clay to boulders. Sediment deposition is largely in the form of alluvial fans (debris flows, sheet wash, and braided streams) which coalesce to form discontinuous, gradational, and poorly sorted deposits. Eolian sand, playa deposits and rare basalt flows are also present within the alluvium section of some valleys. The alluvium thickness in major valleys (e.g. Frenchman Flat and Yucca Flat) generally ranges from about 30 m (100 ft) to over 1,138 m (3,732 ft) at Well ER-5-4.

The alluvial aquifer HSU is confined primarily to the basins of the NTS (Figure 7.4). However, because the water table in the vicinity is moderately deep, the alluvium is generally unsaturated, except in the deep sub-basins of some valleys. These sediments are porous, and thus, have high storage coefficients. Transmissivities may also be high, particularly in the coarser, gravelly beds.

STRUCTURAL CONTROLS

Geologic structures are an important component of the hydrogeology of the area. Structures define the geometric configuration of the area, including the distribution, thickness, and orientation of units. Synvolcanic structures, including caldera faults and some normal faults had strong influence on depositional patterns of many of the units. Juxtapositioning of units with different hydrologic properties across faults may have significant hydrogeologic consequences. Also, faults may act as either conduits of groundwater flow, depending on the difference in permeability between a fault zone and the surrounding rocks. This is partially determined by whether the fault zone is characterized by open fractures, or if it is associated with fine-grained gouge or increased alteration.

Five main types of structural features exist in the area:

- Thrust faults (e.g. Belted Range and CP thrusts).
- Normal faults (e.g. Yucca and West Greeley faults).
- Transverse faults and structural zones (e.g. Rock Valley and Cane Spring faults).
- Calderas (e.g. Timber Mountain and Silent Canyon caldera complexes).
- Detachment faults (e.g. Fluorspar Canyon - Bullfrog Hills detachment fault).

The Belted Range thrust fault is the principle pre-Tertiary structure in the NTS region, and thus controls the distribution of pre-Tertiary rocks in the area. The fault can be traced or inferred from Bare Mountain just south of the southwest corner of the NTS area to the northern Belted Range, just north of the NTS, a distance of more than 130 km. It is an east-vergent thrust fault that generally places late Proterozoic to early Cambrian rocks over rocks as young as Mississippian. Several imbricate thrust faults occur east of the main thrust fault. Deformation related to the Belted Range thrust fault occurred sometime between 100 to 250 Ma. Lesser thrusts of similar age are mapped in the area (e.g. the CP and Spotted Range thrusts).

Normal faults in the area are related mainly to basin-and-range extension (e.g. Yucca fault in Yucca Flat and West Greeley fault on Pahute Mesa). Most of them likely developed during and after the main phase of volcanic activity of the SWNVF (Sawyer *et al.*, 1994). The majority of these faults are northwest- to northeast-striking, high angle faults. However, the exact locations, amount of offset along the faults, and character of the faults become increasingly uncertain with depth.

Calderas are probably the most hydrogeologically important features in the NTS area. Volcano-tectonic and geomorphic processes related to caldera development result in abrupt and dramatic lithologic and thickness changes across caldera margins. Consequently, caldera margins (i.e. faults) separate regions with considerably different hydrogeologic character. At least six major calderas have been identified in the SWNVF, a multi-caldera silicic volcanic field that formed by the voluminous eruption of zoned ignimbrites between 16 and 7.5 million years ago (Sawyer et al., 1994). From oldest to youngest the calderas are: Grouse Canyon, Area 20, Claim Canyon, Rainier Mesa, Ammonia Tanks, and Black Mountain calderas. A comprehensive review of past studies and the evolution of concepts on calderas of the SWNVF during the period from 1960 to 1988 is presented in Byers *et al.*, 1989.

HYDRAULIC PROPERTIES

It is difficult to give precise hydraulic conductivity values for NTS HSUs because of their spacial variability (aquifer heterogeneity). Volcanic rocks typically are extremely variable in lithologic character both laterally and vertically, which accounts for some of the observed heterogeneity. In some areas, units of different character are so finely interbedded that they are assigned to a composite unit (e.g. lava flows embedded within zeolitized bedded tuffs) whose overall hydrologic properties are variable. Another cause of heterogeneity is the irregular distribution of the effects of hydrothermal alteration. Hydraulic properties have rarely been measured for specific HSUs, as borehole hydraulic test intervals tended to span HSU contacts. However, laboratory and field measurements of hydraulic conductivity, flow rates, and temperature profiles indicate that almost all of the groundwater at the NTS is moving through fractures (GeoTrans 1995).

General Hydraulic Characteristics of NTS Rocks

The characteristics of rocks that control the density and character of fractures are the primary determinants of their hydraulic properties, and most hydraulic heterogeneity ultimately is related to fracture characteristics such as fracture density, openness, orientation, and other properties. Secondary fracture-filling minerals can drastically obstruct the flow through or effectively seal an otherwise transmissive formation (Drellack *et al.*, 1997; IT 1996c). Fracture density typically increases with proximity to faults, potentially increasing the hydraulic conductivity of the formation; however, the hydrologic properties of faults are not well known. Limited data suggest that the full spectrum of hydraulic properties, from barrier to conduit, may be possible (Blankennagel and Weir 1973; Faunt 1998). Prediction of the influence of any fault on the hydrologic system thus is made very difficult by the uncertainties associated with estimating the hydraulic properties of that fault, complicated by the potential for the fault to juxtapose permeable and less permeable water-bearing units.

Table 7.2 presents a summary of the hydrologic properties of NTS HGUs. The lowest transmissivity values in volcanic rocks at the NTS are typically associated with non-welded ash-flow tuff and bedded tuff (air-fall and reworked tuffs). Although interstitial porosity may be high, the interconnectivity of the pore space is poor, and these relatively incompetent rocks tend not to support open fractures. Secondary alteration of these tuffs (most commonly, zeolitization) ultimately yields a very impermeable unit. As described in Section 7.4, these zeolitized tuffs are considered to be confining units. The equivalent unaltered bedded and non-welded tuffs are considered to be vitric-tuff aquifers, and have intermediate transmissivities.

In general, the most transmissive rocks tend to be moderately to densely welded ash-flow tuffs (welded-tuff aquifer), rhyolite lava flows (lava-flow aquifer), and carbonate rocks (limestone and dolomite). Although their interstitial porosity is low, these competent lithologies tend to be highly fractured, and groundwater flow through these rocks is largely through an interconnected network of fractures (Blankennagel and Weir 1973; GeoTrans 1995).

Effect of Underground Nuclear Explosions on Hydraulic Characteristics

Underground nuclear explosions may affect hydraulic properties of the geologic medium (both long-term and short-term effects). Effects include enhanced permeability from shock-induced fractures, the formation of vertical conduits (e.g., collapse chimneys), and elevated water levels (mounding and over-pressurization of saturated low-permeability units). However, these effects tend to be localized (Borg *et al.*, 1976; Brikowski 1991; Allen *et al.*, 1997), and usually are addressed in the UGTA program on a case-by-case basis or in sub-CAU-scale models, rather than in regional or CAU-level models.

7.5 HYDROGEOLOGY OF THE NTS FORMER TEST AREAS

Most NTS underground nuclear detonations were conducted in three main test areas: (1) Yucca Flat, (2) Pahute Mesa, and (3) Rainier Mesa (including Aqueduct Mesa). Underground tests in Yucca Flat and Pahute Mesa typically were conducted in vertical drill holes, whereas almost all tests conducted in Rainier Mesa were tunnel emplacements. A total of 85 underground tests (85 detonations) were conducted on Pahute Mesa, including about 19 high-yield detonations (200 kilotons [kt] or more). Rainier Mesa hosted 61 underground tests (62 detonations), almost all of which were relatively low-yield (generally less than 20 kt) tunnel-based weapons-effects tests. Yucca Flat was the most extensively utilized test area, hosting 659 underground tests (747 detonations), four of which were high-yield detonations (Allen *et al*., 1997).

In addition to the three main test areas, underground nuclear tests were conducted in Frenchman Flat (ten tests), Shoshone Mountain (six tests), the Oak Spring Butte/Climax Mine area (three tests), the Buckboard Mesa area (three tests), and Dome Mountain (one test with five detonations) (Allen *et al*., 1997). It should be noted that these totals include nine cratering tests (13 total detonations) conducted in various areas of the NTS. Table 7.3 is a synopsis of information about each underground test area at the NTS, and Figure 7.5 is a map showing the areal distribution of underground nuclear tests conducted at the NTS.

The location of each underground nuclear tests is classified as a Corrective Action Site (CAS). These in turn have been grouped into six CAUs, according to the Federal Facilities Agreement and Consent Order (FFACO 1996) between the DOE and the state of Nevada. In general, the CAUs relate to geographical testing areas on the NTS (Figure 7.5). The hydrogeology of the NTS former test areas is summarized in the following sections.

FRENCHMAN FLAT

The Frenchman Flat CAU consists of ten CASs located in the northern part of NTS Area 5 and southern part of Area 11 (Figure 7.5). The detonations were conducted in vertical emplacement holes and two mined shafts. Nearly all the tests were conducted in alluvium above the water table.

Geologic Overview of Frenchman Flat

The stratigraphic section for the Frenchman Flat area consists of (from oldest to youngest) Proterozoic and Paleozoic clastic and carbonate rocks, Tertiary sedimentary and tuffaceous sedimentary rocks, Tertiary volcanic rocks, and Quaternary and Tertiary alluvium (Slate *et al*., 1999). In the northernmost portion of Frenchman Flat, middle to upper Miocene volcanic rocks that erupted from calderas located to the northwest of Frenchman Flat unconformably overlie Ordovician carbonate and clastic rocks. To the south, these volcanic units, including the Ammonia Tanks Tuff, Rainier Mesa Tuff, Topopah Spring Formation, and Crater Flat Group, either thin considerably, interfinger with coeval sedimentary rocks, or pinch out altogether (IT 1998b). Upper-middle Miocene tuffs, lavas, and debris flows from the Wahmonie volcanic center located just west of Frenchman Flat dominate the volcanic section beneath the western portion of the valley. To the south and southeast, most of the volcanic units are absent and Oligocene to middle Miocene sedimentary and tuffaceous sedimentary rocks, which unconformably overlie the Paleozoic rocks in the southern portion of Frenchman Flat, dominate the Tertiary section (Prothro and Drellack 1997). In most of the Frenchman Flat area, upper Miocene to Holocene alluvium covers the older sedimentary and volcanic rocks (Slate *et al*., 1999). Alluvium thicknesses range from a thin veneer along the valley edges to perhaps as much as 1,158 m (3,800 ft) in north central Frenchman Flat.

The structural geology of the Frenchman Flat area is complex. During the late Mesozoic, the region was subjected to compressional deformation which resulted in folding, thrusting, uplift, and erosion of the pre-Tertiary rocks (Barnes et al., 1982). Beginning approximately 16 million years ago, the region has undergone extensional deformation, during which the present basin-and-range topography was developed and the Frenchman Flat basin was formed (Ekren et al., 1968). In the immediate vicinity of Frenchman Flat, extensional deformation has produced east-northeast-trending, left-lateral strike-slip faults and generally north-trending normal faults that displace the Tertiary and pre-Tertiary rocks. Beneath Frenchman Flat, major west-dipping normal faults merge and are probably contemporaneous with strike-slip faults beneath the southern portion of the basin (Grauch and Hudson 1995). Movement along the faults has created a series of relatively narrow, east-dipping, half-graben sub-basins elongated in a northern direction (Figure 7.6).

Hydrogeology Overview of Frenchman Flat

The hydrogeology of Frenchman Flat is fairly complex, but is typical of the NTS area. Although many of the HGU- and HSU-building blocks developed for the NTS vicinity are applicable to the Frenchman Flat basin, several features make Frenchman Flat unique.

! Significant thickness of older (Oligocene to Miocene) Tertiary sediments.
! Proximity to the Wahmonie volcanic center.
! Distribution of the younger volcanic aquifers.
! Presence of northeast-striking strike-slip faults.

The strata in the Frenchman Flat area have been subdivided into five Tertiary-age HSUs (including the Quaternary/Tertiary alluvium) and three pre-Tertiary HSUs to serve as layers for the UGTA Frenchman Flat CAU groundwater model (IT 1998b). In descending order these units are: the AA, the Timber Mountain aquifer (TMA), the Wahmonie volcanic confining unit (WVCU), the tuff confining unit (TCU), the volcaniclastic confining unit (VCU), the LCA, and the LCCU (Table 7.4).

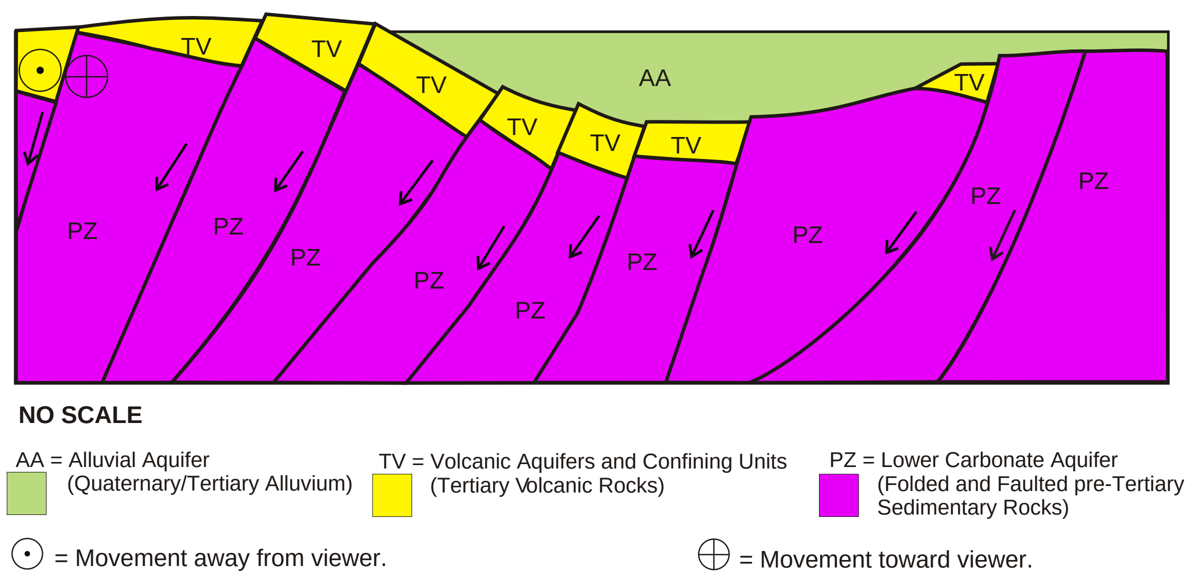


Figure 7.6 Conceptual East-West Cross Section Through Frenchman Flat Showing Sub-Basins Formed by Fault Blocks

Water-level Elevation and Groundwater Flow Direction

The depth to the static water level (SWL) in Frenchman Flat ranges from 210 m (690 ft) near the central playa to more the 350 m (1,150 ft) at the northern end of the valley. The SWL is generally located within the AA, TMA, WVCU or TCU. In the deeper, central portions of the basin, more than half of the alluvium section is saturated. Water-level elevation data in the AA indicate a very flat water table (Blout et al., 1994; IT 1998b). Unfortunately, the poor areal distribution of wells precludes high confidence in any inferred groundwater flow direction for the shallow (alluvial) aquifer.

Water-level data for the LCA in the southern part of the NTS are limited, but indicate a fairly low gradient in the Yucca Flat, Frenchman Flat, and Jackass Flats area. This gentle gradient implies a high degree of hydraulic continuity within the aquifer, presumably due to high fracture permeability (Laczniak et al., 1996). Furthermore, the similarity of the water levels measured in Paleozoic rocks (LCA) in Yucca Flat and Frenchman Flat implies that, at least for deep interbasin flow, there is no groundwater barrier between the two basins. Inferred regional groundwater flow through Frenchman Flat is to the south-southwest toward discharge areas in Ash Meadows (Figure 7.3). An increasing westward flow vector in southern NTS may be due to preferential flow paths subparallel to the east-northeast-trending Rock Valley fault (Grauch and Hudson 1995) and/or a northward gradient from the Spring Mountain recharge area (IT 1996a; b).

Groundwater elevation measurements for wells completed in the AA and TMA are higher than those in the underlying LCA (IT 1996b; 1998b). This implies a downward gradient. This apparent semi-perched condition is believed to be due to the presence of intervening TCU and VCU units.

In the effort to predict and model potential pathways for radiological contaminants from nuclear tests conducted in the AA to reach the regional groundwater system, the possibility of communication between the local aquifers, AA or TMA, and the regional LCA must be addressed. Such pathways could be possible, as explored in the following scenarios:

- Communication via a fault (enhanced permeability due to fracturing near the fault).
- Juxtaposition of the AA or TMA against the LCA due to displacement along a fault.
- Direct communication from the AA and the TMA to the LCA where the TCU, WVCU, or VCU are absent and the AA is in direct contact with the LCA.

YUCCA FLAT

The Yucca Flat/Climax Mine CAU consists of 717 CASs located in NTS Areas 1, 2, 3, 4, 6, 7, 8, 9, 10, and three CASs located in Area 15 (Figure 7.5). These tests were typically conducted in vertical emplacement holes and a few related tunnels (Table 7.3).

The Yucca Flat and Climax Mine testing area were originally defined as two separate CAUs (CAU 97 and CAU 100) in the FFACO (1996) because the geologic frameworks of the two areas are distinctly different. The Yucca Flat underground nuclear tests were conducted in alluvial, volcanic, and carbonate rocks, whereas the Climax Mine tests were conducted in an igneous intrusion in northern Yucca Flat. However, particle-tracking simulations performed during the regional evaluation (IT 1997) indicated that the local Climax Mine groundwater flow system merges into the much larger Yucca Flat groundwater flow system during the 1,000-year time period of interest, so the two areas were combined into the single CAU 97.

Yucca Flat was the most heavily used testing area on the NTS (Figure 7.5). The alluvium and tuff formations provide many characteristics advantageous to the containment of nuclear explosions. They are easily mined or drilled. The high-porosity overburden (alluvium and vitric tuffs) will accept and depressurize any gas which might escape the blast cavity. The deeper tuffs are zeolitized, which creates a nearly impermeable confining unit. The zeolites also have absorptive and “molecular sieve” attributes which severely restrict or prevent the migration of radionuclides. The deep water table (503 m [1,650 ft]) provides additional operational and environmental benefits.

This section provides descriptions of the geologic and hydrogeologic setting of the Yucca Flat area, as well as a discussion of the hydrostratigraphic framework. This summary was compiled from various sources, including Gonzales and Drellack (1999), Winograd and Thordarson (1975), Laczniak *et al*., (1996), Byers *et al*., (1989), and Cole (1997) where additional information can be found.

Geology Overview of Yucca Flat

Yucca Flat is a topographically closed basin with a playa at its southern end (Figure 7.4). The geomorphology of Yucca Flat is typical of the arid, inter-mountain basins found throughout the Basin and Range province of Nevada and adjoining states. Faulted and tilted blocks of Tertiary-age volcanic rocks and underlying Precambrian and Paleozoic sedimentary rocks form low ranges around the basin (Figure 7.4). These rocks also compose the “basement” of the basin, which is now covered by alluvium.

The Precambrian and Paleozoic rocks of the NTS area consist of approximately 11,300 m (37,000 ft) of carbonate and silicic clastic rocks (Cole 1997). These rocks were severely deformed by compressional movements during Mesozoic time, which resulted in the formation of folds and thrust faults (e.g. Belted Range and CP thrust faults). During the middle Late Cretaceous granitic bodies (such as the Climax stock in northern Yucca Flat) intruded these deformed rocks (Maldonado 1977; Houser and Poole 1960). During Cenozoic time, the sedimentary and intrusive rocks were buried by thick sections of volcanic material deposited in several eruptive cycles from source areas in the SWNVF. The volcanic rocks include primarily ash-flow tuffs, ash-fall tuffs, and reworked tuffs, whose thicknesses and extents vary partly due to the irregularity of the underlying depositional surface, and partly due to the presence of topographic barriers and windows between Yucca Flat and the source areas to the north and west.

Large-scale normal faulting began in the Yucca Flat area in response to regional extensional movements near the end of this period of volcanism. This faulting formed the Yucca Flat basin, and as fault movement continued, blocks between faults were down-dropped and tilted, creating subbasins within the Yucca Flat basin. Over the last several million years, gradual erosion of the highlands that surround Yucca Flat has deposited a thick blanket of alluvium on the tuff section. The thickness of the alluvium in the Yucca Flat basin varies as a function of the topography of the underlying deposits and due to continuing movements along faults during alluvium deposition.

The structure of the pre-Tertiary rocks is complex and poorly known, but it is important because the pre-Tertiary section is very thick and extensive and includes units which form regional aquifers. The main pre-Tertiary structures in the Yucca Flat area are related to the east-vergent Belted Range thrust fault which has placed Late Proterozoic to Cambrian-age rocks (LCA3) over rocks as young as Late Mississippian (UCCU) (Cole 1997; Cole and Cashman 1999). In several places along the western and southern portions of Yucca Flat, east-vergent structures related to the Belted Range thrust were deformed by younger west-vergent structural activity (Cole and Cashman 1999). This west-vergent deformation is related to the CP thrust fault which also placed LCA3 over UCCU (Caskey and Schweickert 1992).

The more recent large-scale extensional faulting in the Yucca Flat area is significant because the faults have profoundly affected the hydrogeology of the Tertiary volcanic units by controlling to a large extent their alteration potential and final geometry. In addition, the faults themselves may facilitate flow of potentially contaminated groundwater from sources in the younger rocks into the underlying regional aquifers. The major basin-forming faults generally strike in a northerly direction, and relative offset is typically down to the east (e.g. Yucca, Topgallant, and Carpetbag faults). Movement along the Yucca fault in central Yucca Flat indicates deformation in the area has continued into the Holocene (Hudson 1992).

The configuration of the Yucca Flat basin is illustrated on the generalized west-east cross section shown in Figure 7.7. The cross section is simplified to show the positions of only the primary hydrostratigraphic units in the region. This cross section provides a conceptual illustration of the irregular Precambrian and Paleozoic rocks overlain by the Tertiary volcanic units, and the basin-filling alluvium at the surface. The main Tertiary-age, basin-forming large-scale normal faults are also shown.

Hydrogeology Overview of Yucca Flat

All the rocks of the Yucca Flat study area can be classified as one of eight hydrogeologic units, which include the alluvial aquifer, four volcanic hydrogeologic units, an intrusive unit, and two hydrogeologic units that represent the pre-Tertiary rocks (Table 7.1).

The strata in the Yucca Flat area have been subdivided into eleven Tertiary-age HSUs (including the Tertiary/Quaternary alluvium), one Mesozoic intrusive HSU, and six Paleozoic HSUs (Gonzales and Drellack 1999). These units are listed in Table 7.5, and several of the more important HSUs are discussed in the following paragraphs. The pre-Tertiary HSUs in Yucca Flat are as defined in Section 7.4.

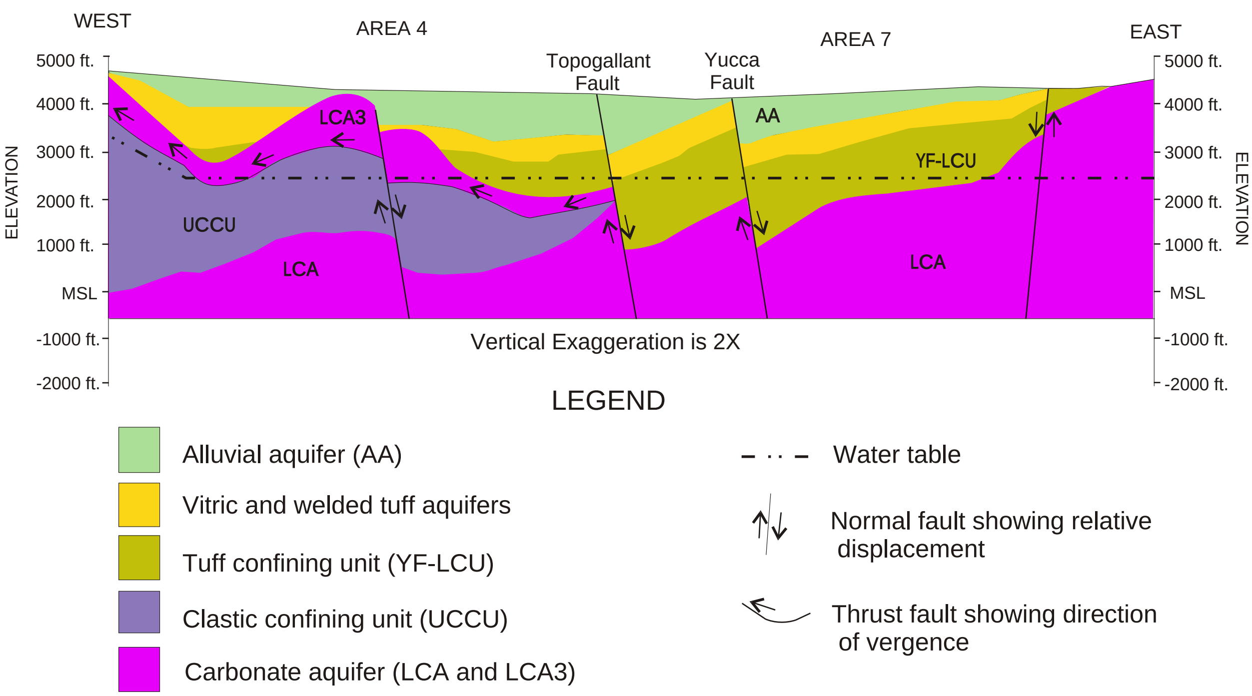


Figure 7.7 Generalized West-East Hydrogeologic Cross Section Through Central Yucca Flat

***Mesozoic Granite Confining Unit* (MGCU)**
Climax stock, a Cretaceous granitic body, is exposed at the north end of Yucca Flat. The hydrologic properties of the granite differ from those of the LCA rocks into which it intruded. Based on observations at the Climax site, the granite has very low permeability and is considered to be a confining unit, though locally, fractures may contain perched water. Because of its location at the up-gradient end of Yucca Flat, this intrusive may contribute to the steep hydraulic gradient in this area.

Yucca Flat Lower Confining Unit (YF-LCU)
The Yucca Flat lower confining unit is an important HSU in the Yucca Flat region (stratigraphically similar to the TCU in Frenchman Flat) because it separates the volcanic aquifer units from the underlying regional LCA. Almost all zeolitized tuff units in Yucca Flat are grouped within the YF-LCU, which comprises mainly zeolitized bedded tuff (air-fall tuff, with minor reworked tuff). In the lower part of the section, several zeolitized nonwelded to partially welded ash-flow tuff units (e.g. Yucca Flat Tuff, Redrock Valley Tuff, tuff of Twin Peaks) are also included. Stratigraphically, the YF-LCU may include all the Tertiary volcanic strata from the top of the Paleozoic rocks to the base of the Rainier Mesa Tuff.

The YF-LCU is generally present in the eastern two-thirds of Yucca Flat. It is absent over the major structural highs, where the volcanic rocks have been removed by erosion. Areas where the YF-LCU is absent include the “Paleozoic bench” in the western portion of the basin. In northern Yucca Flat the YF-LCU tends to be confined to the structural sub-basins. Outside the sub-basins and around the edges of Yucca Flat the volcanic rocks are thinner and are not zeolitized (and thus are classified with lower Timber Mountain vitric-tuff aquifer).

The YF-LCU is saturated in much of Yucca Flat; however, measured transmissivities are very low.

Topopah Spring Aquifer (TSA)
The Topopah Spring aquifer is highly transmissive but is limited in areal extent. The TSA can be more than 100 m (332 ft) thick in southern Yucca Flat, but the unit thins to the east in the Halfpint Range, and to the south in the CP Basin and in northern Frenchman Flat. The TSA is absent west of the Topgallant fault where the volcanic strata have been eroded away. Overall, the hydraulic properties of the TSA are typical of many welded-tuff aquifers in the NTS vicinity.

Timber Mountain Hydrostratigraphic Units
The unaltered volcanic rocks of the Yucca Flat area are divided into three Timber Mountain HSUs. The hydrogeology of this part of the geologic section is complicated by the presence of one or more ash-flow tuff units that are quite variable in properties both vertically and laterally. The Timber Mountain Group includes ash-flow tuffs that might be either welded-tuff aquifers or vitric-tuff aquifers, depending on the degree of welding. In Yucca Flat these units are generally present in the central portions of the basin. They can be saturated in the deepest structural subbasins.

Alluvial Aquifer (AA)
The alluvium in Yucca Flat is similar to that described in Section 7.4. The role of the impermeable playa deposits (underlying Yucca Lake, at the southern end of Yucca Flat) may have profound hydrologic effects, especially its role in controlling recharge, but is only of local concern. Two (or more) basalt flows that have been identified within the alluvium section (Fernald *et al*., 1975) are limited in areal extent and thickness, and therefore are included in the alluvial aquifer. The alluvium thickness in the middle of the Yucca Flat basin generally ranges from about 30 m (100 ft) to just over 800 m (2,625 ft).

Because the water table is moderately deep in the Yucca Flat area, the alluvium is generally unsaturated, except in the deep structural sub-basins, or half grabens, of central Yucca Flat. These sediments are porous, and thus, have high storage coefficients. Transmissivities may also be high, particularly in the coarser, gravelly beds.

Water-level Elevation and Groundwater Flow Direction

Water-level data are abundant for Yucca Flat, as a result of more than thirty years of drilling in the area in support of the weapons testing program. However, water-level data for the surrounding areas are scarce. These data are listed in the potentiometric data package prepared for the regional model (IT 1996b; Hale *et al.*, 1995).

The SWL in the Yucca Flat basin is relatively deep, ranging in depth from about 183 m (600 ft) in extreme western Yucca Flat to more than 580 m (1,900 ft) in north-central Yucca Flat. Elevation of the water table in the Yucca Flat area varies from 1,340 m (4,400 ft) above Mean Sea Level in the north to 730 m (2,400 ft) at the southern end of Yucca Flat (Laczniak *et al.*, 1996; Hale *et al.*, 1995). Throughout much of the Yucca Flat area, the SWL typically is located within the lower portion of the volcanic section, in the Yucca Flat lower confining unit (YF-LCU). Beneath the hills surrounding Yucca Flat, the SWL can be within the Paleozoic units, while in the deeper structural subbasins of Yucca Flat, the Timber Mountain Tuff and the lower portion of the alluvium are also saturated.

Fluid levels measured in wells completed in the AA and volcanic units in the eastern two-thirds of Yucca Flat are typically about 20 m (70 ft) higher than in wells completed in the LCA (Winograd and Thordarson 1975; IT 1996b). The hydrogeology of these units suggests that the higher elevation of the water table in the overlying Tertiary rocks is related to the presence of low permeability zeolitized tuffs of the tuff confining unit (aquitard) between the Paleozoic and Tertiary aquifers. Detail water-level data indicate the existence of a groundwater trough along the axis of the valley. The semi-perched water within the AA, and volcanic aquifers eventually moves downward to the LCA in the central portion of the valley.

Water-level elevations in western Yucca Flat are also well above the regional water level. The hydrology of western Yucca Flat is influenced by the presence of the UCCU, which directly underlies the carbonate aquifer of the upper plate of the CP thrust (LCA3, locally present), AA, and volcanic rocks west of the Topgallant fault. This geometry is a contributing factor in the development of higher (semi-perched) water levels in this area. The Climax stock also bears perched water (Walker 1962; Laczniak *et al.*, 1996) well above the regional water level.

Anomalously high potentiometric head measurements noted in parts of central Yucca Flat have been related to over-pressurization of the saturated zeolitized tuffs, resulting in elevated potentiometric surfaces with increasing depth (Hawkins *et al.*, 1989; Hale 1995). This phenomenon is believed to be caused by underground nuclear tests that were conducted in this area.

The present structural interpretation for Yucca Flat depicts the LCCU at great depth, except in the northeast corner of the study area. The Zabriskie Quartzite and Wood Canyon Formation, which are both classified as clastic confining units, are exposed in the northern portion of the Halfpint Range. The high structural position of the LCCU there (and possibly in combination with the Climax stock) may be at least partially responsible for the steep hydrologic gradient observed between western Emigrant Valley and Yucca Flat.

Based on the existing data and as interpreted from the regional groundwater flow model (DOE 1997c), the overall groundwater flow direction in the Yucca Flat area is to the south and southwest (Figure 7.3). Groundwater ultimately discharges at Franklin Lake Playa to the south and Death Valley to the southwest.

PAHUTE MESA

The Western and Central Pahute Mesa CAUs, encompassing Areas 19 and 20 of the NTS, were the site of 85 underground nuclear tests (DOE 2000) (Figure 7.5). These detonations were all conducted in vertical emplacement holes (Table 7.3). The Western Pahute Mesa CAU is separated from the Central Pahute Mesa by the Boxcar fault and is distinguished by a relative abundance of tritium (IT 1999b). For hydrogeologic studies and modeling purposes, these two CAUs are treated together.

Hydrogeologically, these CAUs are considered to be part of a larger region that includes areas both within and outside the boundaries of the NTS, designated as the Pahute Mesa-Oasis Valley (PM-OV) study area. Because most of the underground nuclear tests at Pahute Mesa were conducted near or below the static water level, test-related contaminants are available for transport via a groundwater flow system that may extend to discharge areas in Oasis Valley. So, like the former testing areas of Frenchman Flat and Yucca Flat, a CAU-level hydrostratigraphic framework model is also being developed for the PM-OV area to support modeling of groundwater flow and contaminant transport for the UGTA program.

Geology Overview of Pahute Mesa

Pahute Mesa is a structurally high-volcanic plateau in the northwest portion of the NTS (Figure 7.4). This physiographic feature covers most of NTS Areas 19 and 20, which are the second most utilized testing area at the NTS. Consequently, there are numerous drill holes which provide a substantial amount of subsurface geologic and hydrologic information (Warren *et al*., 2000). Borehole and geophysical data indicate the presence of several nested calderas which produced thick sequences of rhyolite tuffs and lavas. The older calderas are buried by ash-flow units produced from younger calderas. Most of eastern Pahute Mesa is capped by the voluminous Ammonia Tanks and Rainier Mesa ash-flow tuff units which erupted from the Timber Mountain Caldera, located immediately to the south of Pahute Mesa (Byers *et al*., 1976). The western portion is capped by ash-flows of the Thirsty Canyon Group from the Black Mountain caldera. A typical geologic cross section for Pahute Mesa is presented in Figure 7.8. For a more detailed geologic summary, see Ferguson, *et al*., (1994), Sawyer, *et al*., (1994), and BN (2001a).

Underlying the Tertiary volcanic rocks (exclusive of the caldera complexes) are Paleozoic and Proterozoic sedimentary rocks consisting of dolomite, limestone, quartzite, and argillite. During Precambrian and Paleozoic time, as much as 9,600 m (31,500 ft) of these marine sediments were deposited in the NTS region (Cole 1997). For detailed stratigraphic descriptions of these rocks see Slate *et al*., (1999).

The only occurrence of Mesozoic age rocks in this area is the Gold Meadows stock, a granitic intrusive mass located at the eastern edge of Pahute Mesa, north of Rainier Mesa (Snyder 1977; Gibbons et al.,1963).

The Silent Canyon caldera complex (SCCC) lies beneath Pahute Mesa. This complex contains the oldest known calderas within the SWNVF, and is completely buried by volcanic rocks erupted from younger nearby calderas. It was first identified from gravity observations that indicated a

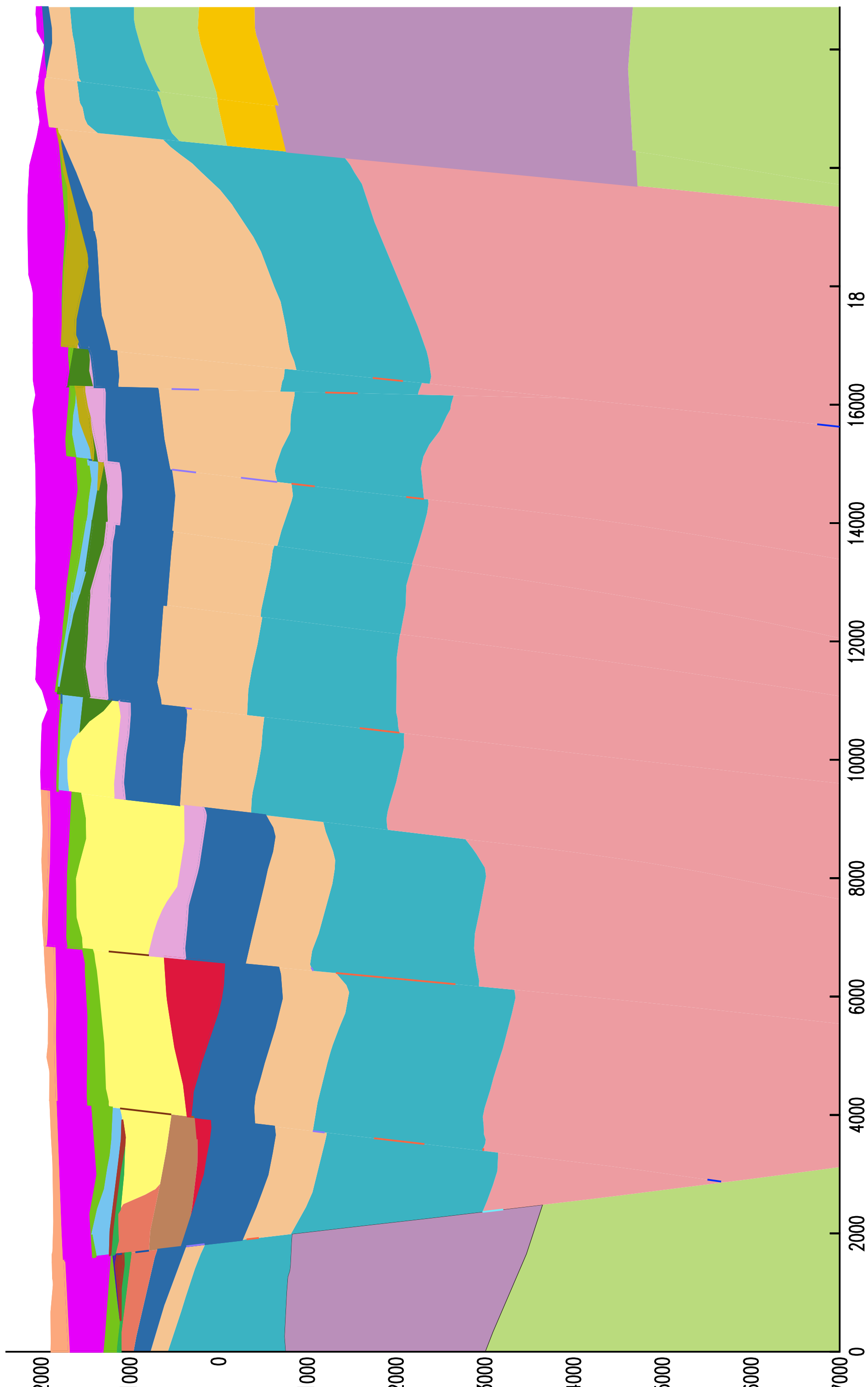


Figure 7.8 Generalized Geologic Cross Section Through Pahute Mesa

deep basin below the topographically high Pahute Mesa. Subsequent drilling on Pahute Mesa indicated that the complex consists of at least two nested calderas, the Grouse Canyon caldera and younger Area 20 caldera (13.7 and 13.25 million years old, respectively; Sawyer *et al.*, 1994). For more information on the SCCC, see Ferguson et al. (1994), which is a comprehensive study of the caldera complex based on analysis of gravity, seismic refraction, drill hole, and surface geologic data.

Like the Silent Canyon caldera complex, the Timber Mountain caldera complex (TMCC) consists of two nested calderas, the Rainier Mesa caldera and younger Ammonia Tanks caldera, 11.6 and 11.45 million years old, respectively (Sawyer *et al.*, 1994). However, unlike the SCCC, the TMCC has exceptional topographic expression, consisting of an exposed topographic margin for more than half its circumference and a well exposed central resurgent dome (Timber Mountain, the most conspicuous geologic feature in the western part of the NTS). The complex truncates the older Claim Canyon caldera (12.7 million years old; Sawyer *et al.*, 1994) in the southern portion of the model area. The calderas of the TMCC are the sources for the Rainier Mesa and Ammonia Tanks Tuffs, which form important and extensive hydrostratigraphic units at the NTS and vicinity.

The Black Mountain caldera is a relatively small caldera in the northwest portion of the Pahute Mesa area. It is the youngest caldera in the area, formed as a result of the eruption, 9.4 million years ago, of tuffs assigned to the Thirsty Canyon Group (Sawyer *et al.*, 1994).

Deep gravity lows and the demonstrated great thickness of tuffs in the Pahute Mesa area suggest the presence of older buried calderas. These calderas would pre-date the Grouse Canyon caldera and thus, could be the source of some of the pre-Belted Range units.

Hydrogeology Overview of Pahute Mesa

The general hydrogeologic framework for Pahute Mesa and vicinity was established in the early 1970s by USGS geoscientists (Blankennagel and Weir 1973; Winograd and Thordarson 1975). As described in Section 7.4, their work has provided the foundation for most subsequent hydrogeologic studies at the NTS (IT 1996a; BN 2001a).

The hydrogeology of PM-OV area is complex. The thick section of volcanic rocks comprises a wide variety of lithologies that range in hydraulic character from aquifer to aquitard. The presence of several calderas and tectonic faulting further complicate the area, placing the various lithologic units in juxtaposition, and blocking or enhancing the flow of groundwater in a variety of ways.

All the rocks in the PM-OV area can be classified as one of nine hydrogeologic units, which include the alluvial aquifer, four volcanic hydrogeologic units, two intrusive units, and two hydrogeologic units that represent the pre-Tertiary rocks (Table 7.1).

The rocks within the PM-OV area are grouped into 46 HSUs for the UGTA framework model (Table 7.6). The volcanic units are organized into 40 HSUs that include 16 aquifers, 13 confining units, and 11 composite units (comprising a mixture of hydraulically variable units). The underlying pre-Tertiary rocks are divided into six HSUs, including two aquifers and four confining units. HSUs that are common to several CAUs at the NTS are briefly discussed in Section 7.4.

The structural setting of the Pahute Mesa area is dominated by the calderas described in the previous paragraphs. Several other structural features are considered to be significant factors in the hydrology, including the Belted Range thrust fault (see Section 7.4), numerous normal faults related mainly to basin-and-range extension, and transverse faults and structural zones. However, many of these features are buried, and their presence is inferred from drilling and geophysical data.

Normal Faults
Most of the normal faults are northwest- to northeast-striking high angle faults; however, the exact locations, amount of offset along the faults, and character of the faults become increasingly uncertain with depth. Most of the normal faults in the Pahute Mesa area likely developed during and after the main phase of volcanic activity of the SWNVF (Sawyer *et al.*, 1994). Many of the faults at Pahute Mesa are believed to be syn-volcanic faults that experienced episodic movement during the various eruptive events in the area (Ferguson, et al., 1994 and Warren *et al.*, 2000). Some of the normal faults at Pahute Mesa are also caldera faults (Ferguson, *et al.*, 1994 and Warren *et al.*, 2000).

Transverse Faults and Structural Zones
Several transverse faults and structural zones have also been mapped and/or inferred through geophysical studies. These structural features include generally west to west-northwest striking high-angle faults and structural zones that are oriented transverse to generally north-striking basin-and-range normal faults. (Warren *et al*. 1985; Ferguson *et al*. 1994; Warren *et al*. 2000; Grauch *et al*. 1997, 2000, Mankinen *et al*. 1999, and Fridrich *et al*. 1999). Many of these structural features appear to be related to both caldera formation and basin-and-range extension.

Calderas
As mentioned above, calderas are hydrogeologically important features in the PM-OV area, both as sources of thicknesses of volcanic rocks, and because structures associated with them affect groundwater flow. Volcano-tectonic and geomorphic processes related to caldera development result in abrupt and dramatic changes in lithology and unit thicknesses across caldera margins. Also, the faults that form the margins themselves are probably hydrologically significant as barriers to or conduits for groundwater flow. Hydrothermal alteration, which tends to reduce hydraulic conductivity, is common around caldera complexes.

Water-level Elevation and Groundwater Flow Direction

Water-level data are relatively abundant for the former underground test area on Pahute Mesa in the northwestern portion of the NTS, as a result of more than thirty years of drilling in the area in support of the weapons testing program. However, water-level data for the outlying areas to the west and south are sparse. These data are listed in the potentiometric data package prepared for the regional model (IT 1996b), and the Pahute Mesa water table map (O'Hagan and Laczniak 1996).

The SWL at Pahute Mesa is relatively deep, at about 640 m (2,100 ft) below the ground surface. Anomalously high water levels have been encountered in several drill holes on Pahute Mesa. This water is believed to be perched (Hershey and Brikowski, 1995; O'Hagan and Laczniak, 1996). Groundwater flow at Pahute Mesa is driven by recharge in the east and subsurface inflow from the north. Local groundwater flow is influenced by the discontinuous nature of the volcanic aquifers and the resultant geometry created by overlapping caldera complexes and high angle basin and range faults (Laczniak *et al.*, 1996). Potentiometric data indicate that groundwater flow direction is to the southwest toward discharge areas in Oasis Valley and ultimately Death Valley.

RAINIER MESA

Rainier Mesa/Shoshone Mountain CAU consists of 60 CASs on Rainier Mesa and six on Shoshone Mountain, which are located in NTS Areas12 and 16 respectively (Figure 7.5). Rainier Mesa and Aqueduct Mesa form the southern extension of the northeast trending Belted Range (Figure 7.4). Together, these two mesas constitute the third major area utilized for underground testing of nuclear weapons at the NTS between 1957 and 1992. Weapons effects tests were conducted in horizontal, mined tunnels within these mesas, and two tests were conducted in vertical drill holes. Underground geologic mapping data from the numerous tunnel complexes, and lithologic and geophysical data from dozens of exploratory drill holes, provide a wealth of geologic and hydrologic information for this relatively small test area.

Geology Overview of Rainier Mesa and Shoshone Mountain

Both mesas are composed of Miocene age air-fall and ash-flow tuffs, which were erupted from nearby calderas to the west and southwest. As in Yucca Flat, these silicic volcanic tuffs were deposited unconformably on an irregular pre-Tertiary (upper Precambrian and Paleozoic) surface of sedimentary rocks (Gibbons *et al.*, 1963; Orkild 1963). The stratigraphic units and lithologies are similar to those present in the subsurface of Yucca Flat (Section 7.5). Most of Rainier Mesa and Shoshone Mountain consist of zeolitized bedded tuff, though the upper part of this section is unaltered (vitric) in some areas. At both locations, the bedded tuffs are capped by a thick layer of welded ash-flow tuff. The trace of the CP thrust fault extends through the pre-Tertiary rocks of Rainier Mesa, and several high-angle, normal faults have been mapped in the volcanic rocks at both test areas. Most of the tests in Shoshone Mountain and Rainier Mesa tunnels were conducted in the tuff confining unit, though a few were conducted in vitric bedded tuff higher in the stratigraphic section.

Hydrogeology Overview of Rainier Mesa and Shoshone Mountain

Construction of UGTA CAU-level models for the Rainier Mesa and Shoshone Mountain test areas has not yet begun. However, HGUs and HSUs in the Rainier Mesa and Shoshone Mountain area are expected to be similar to those defined for the Yucca Flat area (see Table 7.5).

Water-level Elevation and Groundwater Flow Direction

The SWL at Rainier Mesa is at a depth of about 258 m (846 ft), or about 1,847 m (6,061 ft) elevation above Mean Sea Level, and typically within the TCU. This anomalously high water level relative to the regional water level reflects the presence of water perched above the underlying tuff confining units (Walker 1962; Laczniak *et al.*, 1996). Abundant water is present in the fracture systems of some of the tunnel complexes at Rainier Mesa. This water currently is permitted to flow from U12eTunnel; however water has filled the open drifts behind barriers built near the portals of U12n and U12t Tunnels.

The water level elevation at Shoshone Mountain is not known.

Regional groundwater flow from Rainier Mesa may be directed either toward Yucca Flat or, because of the intervening UCCU, to the south toward Alkali Flat discharge area (Figure 7.3). The groundwater flow direction beneath Shoshone Mountain is probably southward as indicated in Figure 7.3.

7.6 CONCLUSION

The hydrogeology of the NTS and vicinity is complex and varied. Yet, the remote location, alluvial and volcanic geology, and deep water table of the NTS provided a favorable setting for conducting and containing underground nuclear tests. Its arid climate and its setting in a region of closed hydrographic basins also are factors in stabilizing residual surficial contamination from atmospheric testing, and are considered positive environmental attributes for existing radioactive waste management sites.

Average groundwater flow velocities at the NTS are generally slow, and flow paths to discharge areas or potential receptors (domestic and public water supply wells) are long. The water table for local aquifers in the valleys and the underlying regional carbonate aquifer are relatively flat. The zeolitic volcanic formations (TCU) separating the shallower alluvial and volcanic aquifers and the regional carbonate aquifer (LCA) appears to be a viable aquitard. Consequently, both vertical and horizontal flow velocities are low. Additionally, ^{14}C dates for water from NTS aquifers are on the order of 10,000 to 40,000 years old (Rose *et al*., 1997). Thus, there is considerable residence time in the aquifers, allowing contaminant attenuating processes such as matrix diffusion, sorbtion, and natural decay, to operate.

It is imperative that those responsible for developing viable monitoring programs understand this unique hydrogeologic setting. As described in this chapter, a vast amount of hydrogeologic data has been acquired in support of NTS programs over the last 40 years, and data continue to be acquired. Now scientists are using these data to develop and improve models for predicting groundwater flow and contaminant transport at the NTS. All of these resources, including databases, groundwater flow models, and subject matter experts, were utilized during the development of the Routine Radiological Environmenal Monitoring Program (RREMP) (DOE 1998a).

Another beneficial consequence of previous and current NTS activities is the availability of an array of boreholes that penetrate the saturated zone. A significant number of these “holes of opportunity” are in optimal locations, with appropriate well completions that provide access to aquifers of interest. Selected monitoring wells and water supply wells, both on and off the NTS, have been incorporated into a monitoring network for the RREMP. Additional wells will become available as the UGTA characterization wells are phased into the RREMP. Analytical results from routine sampling of these wells are reported in Chapter 8.0, “Groundwater Monitoring.”

Table 7.2 Summary of Hydrologic Properties for Hydrogeologic Units at the Nevada Test Site

Hydrogeologic Unit [a]			Fracture Density [b, c]	Relative Hydraulic Conductivity [c]	Hydraulic Conductivity [c, d] (meters/day) Range
Alluvial Aquifer			Very low	Moderate to very high	0.1 - 20
Vitric-Tuff Aquifer			Low	Low to moderate	0.1 - 1
Welded-Tuff Aquifer			Moderate to High	Moderate to very high	1 - 30
Lava-Flow Aquifer [e]	Pumiceous Lava	Vitric	Low	Low to moderate	0.1 - 1
		Zeolitic	Low	Very low	0.001 - 0.7
	Stony Lava and Vitrophyre		Moderate to high	Moderate to very high	1 - 20
	Flow Breccia		Low to Moderate	Low to moderate	0.01 - 2
Tuff Confining Unit			Low	Very low	0.001 - 0.5
Intrusive Confining Unit			Low to Moderate	Very Low	0.001 - 0.5
Granite Confining Unit			Low to Moderate	Very Low	0.001 - 0.5
Carbonate Aquifer			Low to high (variable)	Low to very high	0.01 - 20
Clastic Confining Unit			Moderate	Very low to low [f]	0.001 - 0.2

(a) Refer to Table 7.1 for hydrogeologic nomenclature.

(b) Including primary (cooling joints in tuffs) and secondary (tectonic) fractures.

(c) The values presented are the authors' qualitative estimates based on data from published (IT [1996c] and Blankennagel and Weir [1973], Winograd and Thordarson [1975]) and unpublished sources (i.e., numerous Los Alamos and Lawrence Livermore National Laboratory drill-hole characterization reports).

(d) Because conductivity decreases with depth, the values corresponding to typical saturated depths are presented.

(e) Abstracted from Prothro and Drellack, 1997.

(f) Fractures tend to be sealed by the presence of secondary minerals.

Note: Adapted from Drellack and Prothro, 1997.

Table 7.3 Information Summary of Nevada Test Site Underground Nuclear Tests

Physiographic Area	NTS Area(s)	Total underground[a]		Test dates[a]	Announced high/low yield range (kiloton [kt])[a]	Depth of burial range	Overburden media	Comments
		tests	detonations					
Yucca Flat	1, 2, 3, 4, 6, 7, 8, 9, 10	659	747	1957 - 1992	zero/200 to 500	27 - 1219 m (89 - 3999 ft)	Alluvium/Playa Volcanic Tuff Paleozoic rocks	Various test types and yields; almost all were vertical emplacements above and below static water level.
Pahute Mesa	19, 20	85	85	1966 - 1992	2.3/>1000	31 - 1452 m (100 - 4765 ft)	Alluvium (thin) Volcanic tuffs & lavas	Almost all were large-diameter vertical emplacements above and below static water level; includes 19 high-yield detonations.
Rainier/ Aqueduct Mesa	12	61	62	1958 - 1992	zero/20 to 200 (most < 20)	61 - 640 m (200 - 2100 ft)	Tuffs with welded tuff caprock (little or no alluvium)	Two vertical emplacements; all others were horizontal tunnel emplacements above static water level; mostly low-yield Department of Defense weapons-effects tests.
Frenchman Flat	5, 11	10	10	1965 - 1971	< 20	179 - 296 m (587 - 971 ft)	Mostly alluvium minor volcanics	Various emplacement configurations, both above and below static water level.
Shoshone Mtn.	16	6	6	1962 - 1971	low/< 20	244 - 640 m (800 - 2100 ft)	Bedded Tuff	Tunnel-based low-yield weapons-effects and Vela Uniform tests.
Oak Spring Butte (Climax Area)	15	3	3	1962 - 1966	5.7/62	229 - 351 m (750 - 1150 ft)	Granite	Three tunnel-based tests above static water level. (HARD HAT, TINY TOT, and PILE DRIVER).
Buckboard Mesa	18	3	3	1962 - 1964	0.092/0.5	≤ 27 m (90 ft)	Basaltic Lavas	Shallow, low-yield cratering experiments (SULKY, JOHNNIE BOY[b] and DANNY BOY); all were above static water level.
Dome Mountain	30	1	5	03/12/68	five detonations @ 1.08 kt each	50 m (165 ft)	Mafic Lava	BUGGY (A, B, C, D, and E); Plowshare cratering test of five-shot horizontal salvo; all above static water level.

Note: Source: Allen, *et al.*, 1997.

(a) Source: U.S. Department of Energy (2000).

(b) JOHNNIE BOY was detonated at a depth of 1.75 ft (essentially a surface burst) approximately one mile east of Buckboard Mesa.

Table 7.4 Hydrostratigraphic Units of the Frenchman Flat Area

Hydrostratigraphic Unit (Symbol)	Dominant Hydrogeologic Unit [(a)]	Typical Lithologies
Alluvial Aquifer (AA)	AA, minor LFA	Alluvium (gravelly sand); also includes relatively thin basalt flow in northern Frenchman Flat and playa deposits in south-central part of basin.
Timber Mountain Aquifer (TMA)	WTA, VTA	Welded ash-flow tuff and related nonwelded and air-fall tuffs; vitric to devitrified.
Wahmonie Volcanic Confining Unit (WVCU)	TCU, minor LFA	Air-fall and reworked tuffs; debris and breccia flows; minor intercalated lava flows. Typically altered: zeolitic to argillic.
Tuff Confining Unit (TCU)	TCU	Zeolitic bedded tuffs, with interbedded but less significant zeolitic, nonwelded to partially welded ash-flow tuffs
Volcaniclastic Confining Unit (VCU)	TCU, Minor AA	Diverse assemblage of interbedded volcanic and sedimentary rocks including tuffs, shale, tuffaceous and argillaceous sandstones, conglomerates, minor limestones.
Upper Clastic Confining Unit (UCCU)	CCU	Argillite, quartzite
Lower Carbonate Aquifer (LCA)	CA	Dolomite and limestone
Lower Clastic Confining Unit (LCCU)	CCU	Quartzites and siltstones

(a) See Table 7.1 for descriptions of hydrogeologic units.
Note: Adapted from IT, 1998b.

Table 7.5 Hydrostratigraphic Units of the Yucca Flat Area

Hydrostratigraphic Unit (Symbol)	Dominant Hydrogeologic Units [(a)]	Typical Lithologies
Alluvial Aquifer (AA)	AA, minor LFA	Alluvium (gravelly sand); also includes one or more thin basalt flows, playa deposits and eolian sands
Timber Mountain Upper Vitric-Tuff Aquifer (TM-UVTA)	WTA, VTA	Includes vitric nonwelded ash-flow and bedded tuff
Timber Mountain Welded-Tuff Aquifer (TM-WTA)	WTA	Partially to densely welded ash-flow tuff; vitric to devitrified
Timber Mountain Lower Vitric-Tuff Aquifer (TM-LVTA)	VTA	Nonwelded ash-flow and bedded tuff; vitric
Yucca Flat Upper Confining Unit (YF-UCU)	TCU	Zeolitic bedded tuff
Topopah Spring Aquifer (TSA)	WTA	Welded ash-flow tuff
Belted Range Aquifer (BRA)	WTA	Welded ash-flow tuff
Belted Range Confining Unit (BRCU)	TCU	Zeolitic bedded tuffs
Pre-grouse Canyon Tuff Lava-Flow Aquifer (Pre-Tbg-LFA)	LFA	Lava flow
Tub Spring Aquifer (TUBA)	WTA	Welded ash-flow tuff
Yucca Flat Lower Confining Unit (YF-LCU)	TCU	Zeolitic bedded tuffs with interbedded but less significant zeolitic, nonwelded to partially welded ash-flow tuffs
Mesozoic Granite Confining Unit (MGCU)	GCU	Granodiorite and quartz monzonite
Upper Carbonate Aquifer (UCA)	CA	Limestone
Lower Carbonate Aquifer - Yucca Flat Upper Plate (LCA3)	CA	Limestone and dolomite
Lower Clastic Confining Unit - Yucca Flat Upper Plate (LCCU1)	CCU	Quartzite and siltstone
Upper Clastic Confining Unit (UCCU)	CCU	Argillite and quartzite
Lower Carbonate Aquifer (LCA)	CA	Dolomite and limestone
Lower Clastic Confining Unit (LCCU)	CCU	Quartzite and siltstone

(a) See Table 7.1 for description of hydrogeologic units.
Note: Adapted from Gonzales and Drellack, 1999.

Table 7.6 Hydrostratigraphic Units of the Pahute Mesa-Oasis Valley Area

Hydrostratigraphic Unit (Symbol)	Dominant Hydrogeologic Unit(s)[(a)]	Typical Lithologies
Alluvial Aquifer (AA)	AA	Alluvium (gravelly sand); also includes eolian sand
Younger Volcanic Composite Unit (YVCM)	LFA, WTA, VTA	Basalt, welded and nonwelded ash-flow tuff
Thirsty Canyon Volcanic Aquifer (TCVA)	WTA, LFA, lesser VTA	Partially to densely welded ash-flow tuff; vitric to devitrified
Detached Volcanics Composite Unit (DVCM)	WTA, LFA, TCU	Complex distribution of welded ash-flow tuff, lava, and zeolitic bedded tuff
Fortymile Canyon Composite Unit (FCCM)	LFA, TCU, lesser WTA	Lava flows and associated tuffs
Timber Mountain Composite Unit (TMCM)	TCU (altered tuffs, lavas) and unaltered WTA and lesser LFA	Densely welded ash-flow tuff; includes lava flows, and minor debris flows.
Tannenbaum Hill Lava-Flow Aquifer (THLFA)	LFA	Rhyolitic lava
Tannenbaum Hill Composite Unit (THCM)	Mostly TCU, lesser WTA	Zeolitic tuff and vitric, nonwelded to welded ash-flow tuffs
Timber Mountain Aquifer (TMA)	Mostly WTA, minor VTA	Partially to densely welded ash-flow tuff; vitric to devitrified
Subcaldera Volcanic Confining Unit (SCVCU)	TCU	Probably highly altered volcanic rocks and intruded sedimentary rocks
Fluorspar Canyon Confining Unit (FCCU)	TCU	Zeolitic bedded tuff
Windy Wash Aquifer (WWA)	LFA	Rhyolitic lava
Paintbrush Composite Unit (PCM)	WTA, LFA, TCU	Welded ash-flow tuffs, rhyolitic lava and minor associated bedded tuffs
Paintbrush Vitric-tuff Aquifer (PVTA)	VTA	Vitric, nonwelded and bedded tuff
Benham Aquifer (BA)	LFA	Rhyolitic lava
Upper Paintbrush Confining Unit (UPCU)	TCU	Zeolitic, nonwelded and bedded tuff

(a) See Table 7.1 for definitions of hydrogeologic units.

Table 7.6 (Hydrostratigraphic Units of the Pahute Mesa-Oasis Valley Area, cont.)

Hydrostratigraphic Unit (Symbol)	Dominant Hydrogeologic Unit(s)[a]	Typical Lithologies
Tiva Canyon Aquifer (TCA)	WTA	Welded ash-flow tuff
Paintbrush Lava-Flow Aquifer (PLFA)	LFA	Lava; moderately to densely welded ash-flow tuff
lower Paintbrush Confining Unit (LPCU)	TCU	Zeolitic nonwelded and bedded tuff
Topopah Spring Aquifer (TSA)	WTA	Welded ash-flow tuff
Yucca Mountain Crater Flat Composite Unit (YMCFCM)	LFA, WTA, TCU	Lava; welded ash-flow tuff; zeolitic, bedded tuff
Calico Hills Vitric-tuff Aquifer (CHVTA)	VTA	Vitric, nonwelded tuff
Calico Hills Vitric Composite Unit (CHVCM)	VTA, LFA	Partially to densely welded ash-flow tuff; vitric to devitrified
Calico Hills Zeolitized Composite Unit (CHZCM)	LFA, TCU	Rhyolitic lava and zeolitic nonwelded tuff
Calico Hills Confining Unit (CHCU)	Mostly TCU, minor LFA	Zeolitic nonwelded tuff; minor lava
Inlet aquifer (IA)	LFA	Lava
Crater Flat Composite Unit (CFCM)	Mostly LFA, intercalated with TCU	Lava and welded ash-flow tuff
Crater Flat Confining Unit (CFCU)	TCU	Zeolitic nonwelded and bedded tuff
Kearsarge Aquifer (KA)	LFA	Lava
Bullfrog Confining Unit (BCU)	TCU	Zeolitic, nonwelded tuff
Belted Range Aquifer (BRA)	LFA and WTA, with lesser TCU	Lava and welded ash-flow tuff

(a) See Table 7.1 for definitions of hydrogeologic units.

Table 7.6 (Hydrostratigraphic Units of the Pahute Mesa-Oasis Valley Area, cont.)

Hydrostratigraphic Unit (Symbol)	Dominant Hydrogeologic Unit(s)[(a)]	Typical Lithologies
Pre-Belted Range Composite Unit (PBRCM)	TCU, WTA , LFA	Zeolitic bedded tuffs with interbedded but less significant zeolitic, nonwelded to partially welded ash-flow tuffs
Black Mountain Intrusive Confining Unit (BMICU)	IICU	These units are presumed to be present beneath the calderas of the SWNVF. Their actual character is unknown, but they may be igneous intrusive rocks or older volcanic and pre-Tertiary sedimentary rocks intruded to varying degrees by igneous rocks.
Ammonia Tanks Intrusive Confining Unit (ATICU)	IICU	
Rainier Mesa Intrusive Confining Unit (RMICU)	IICU	
Claim Canyon Intrusive Confining Unit (CCICU)	IICU	
Calico Hills Intrusive Confining Unit (CHICU)	IICU	
Silent Canyon Intrusive Confining Unit (SCICU)	IICU	
Mesozoic Granite Confining Unit (MGCU)	GCU	Granodiorite and quartz monzonite
Lower Carbonate Aquifer - Thrust Plate (LCA3)	CA	Limestone and dolomite
Lower Clastic Confining Unit - Thrust Plate	CCU	Quartzite and siltstone
Upper Clastic Confining Unit (UCCU)	CCU	Argillite and quartzite
Lower Carbonate Aquifer (LCA)	CA	Dolomite and limestone
Lower Clastic Confining Unit (LCCU)	CCU	Quartzite and siltstone

(a) See Table 7.1 for definitions of hydrogeologic units.

Eleana Range (No Date Provided)

8.0 GROUNDWATER MONITORING

The Nevada Test Site (NTS) has a history of underground nuclear testing and continues to operate radioactive waste storage and disposal sites, a hazardous material testing facility, and conducts environmental restoration activities. Groundwater monitoring on and near the NTS is of particular importance due to the existing and potential groundwater contamination resulting from historical nuclear testing activities.

In calendar year (CY) 2000, Bechtel Nevada (BN) contracted with an offsite analytical laboratory. BN has received some results for radioactivity analyses from this laboratory which are somewhat higher than historical data. The organization providing oversight groundwater monitoring operations has also experienced similar difficulty in obtaining accurate analytical data. These laboratory problems have resulted in the reanalysis of some samples and provided the impetus to increase the use of quality control measures. Although some analytical data received in 2000 are of questionable quality, they are generally in good agreement with data collected by the oversight organization and indicate that radionuclides have traveled less than one mile from testing areas and in some locations, significantly less than one mile. Activities conducted within the Underground Testing Area (UGTA) program for year 2000 are described in Chapter 4.0 of this report.

8.1 INTRODUCTION

There have been 828 underground nuclear tests conducted at the NTS. Approximately one third of these tests were detonated near or below the water table (U.S. Department of Energy [DOE] 1996b; DOE 2000). This legacy of nuclear testing has resulted in the contamination of groundwater in some areas. Figure 8.1 indicates the locations of underground nuclear tests and areas of potential groundwater contamination. To safeguard the public's health and safety and comply with applicable federal, state, and local environmental protection regulations as well as DOE directives, groundwater on and near the NTS is monitored for radioactivity. Monitoring in the past has been conducted by the U.S. Public Health Service, USGS, Environmental Protection Agency and others. In 1998, BN was tasked by the U.S. Department of Energy, National Nuclear Security Administration, Nevada Operations Office (NNSA/NV), to establish and manage the NTS Routine Radiological Environmental Monitoring Plan (RREMP), a single integrated and comprehensive monitoring program. The RREMP details groundwater monitoring objectives, regulatory drivers, and quality assurance protocols which are also summarized in Chapter 4.0.

The NTS groundwater monitoring network consists of a variety of monitoring locations to determine if and to what extent aquifers have been impacted by radionuclides originating from activities on the NTS. These locations include onsite supply wells, wells specifically designed to monitor groundwater, natural springs, domestic offsite wells and point of opportunity locations. The onsite and offsite locations sampled in 2000 along with the predicted groundwater flow paths are presented in Figures 8.2 and 8.3, respectively. The NTS groundwater monitoring locations are located in a complex hydrogeologic setting which has been described in Chapter 7.0.

8.2 GROUNDWATER MONITORING ANALYTES

The analytes of interest for groundwater monitoring are based on the radiological source term from historical nuclear testing, regulatory/permit requirements, and characterization needs. Typical analyses are presented in Table 8.1 and include both radiological and chemical parameters to assess impacts to aquifers from past nuclear testing and to characterize the groundwater system. The sampling frequency presented in Table 8.1 is based on well type and location. The isotopic inventory remaining from nuclear testing is presented in the NTS Environmental Impact Statement (DOE, 1996c) and a recent Lawrence Livermore National Laboratory (LLNL) document (Smith, 2001). Many of the radioactive species generated from subsurface testing have very short half-lives, sorb strongly onto the solid phase or are bound into what is termed “puddle glass” and are not available for groundwater transport in the near term (Smith, 1993 and Smith *et al.*, 1995). Tritium is the radioactive species created in the greatest quantities and is widely believed to be one of the most mobile. Tritium is therefore the primary target analyte and represents the greatest concern to users of groundwater on and around the NTS for at least the next 100 years due to its high mobility and concentration (DOE 1996c; International Technology [IT] 1997).

The majority of tritium results presented in this chapter are from enriched samples. Tritium samples are enriched to achieve a very low detection limit. The enrichment process concentrates tritium in the samples to give an effective minimum detectable concentration (MDC) of near 10 pCi/L whereas the MDC for a standard (non-enriched) tritium analysis ranges from 200-400 pCi/L. The uncertainty/error values presented in the summary tables at the end of this chapter represent the counting uncertainty/error of the analytical method. Although the uncertainty associated with the enrichment process has not yet been quantified, it is estimated to be up to 20 percent and is not encompassed by the counting uncertainty/error. It is therefore important to note that the total or system error associated with the enrichment and analysis process for tritium samples is somewhat higher than the values presented in the summary tables.

8.3 GROUNDWATER MONITORING RESULTS

TRITIUM

Onsite Supply Wells

Results from all samples collected from the water supply wells for tritium analyses were well below the regulatory standard of 20,000 pCi/L. Only wells 4, 4A, J-12, J-13 and C-1 had reported concentrations above the MDC. Wells 4, 4A, J-12 and J-13 had fourth quarter results of less than 35 pCi/L and do not have a history of detectable levels of tritium. The fourth quarter tritium analyses were performed by a newly contracted laboratory. This change in analytical laboratories may account for the variability as compared to past results due to differences in instrumentation and concentration of background samples. In consideration of these differences, it is not believed that the onsite water supply network has been impacted by subsurface nuclear testing .

Water Well C-1 was injected with approximately 0.1 to 0.2 Curies of tritium by a researcher conducting a tracer test in 1962 (Lyles, 1990). Figure 8.4 is a time series plot of tritium concentrations for locations sampled in 2000 that have a history of detectable tritium. This plot illustrates the decrease of the annually averaged tritium concentrations in Well C-1 over time.

Analytical results for all tritium analyses are presented in Table 8.2. Figure 8.5 shows the locations of wells with a history of detectable tritium that were sampled in 2000.

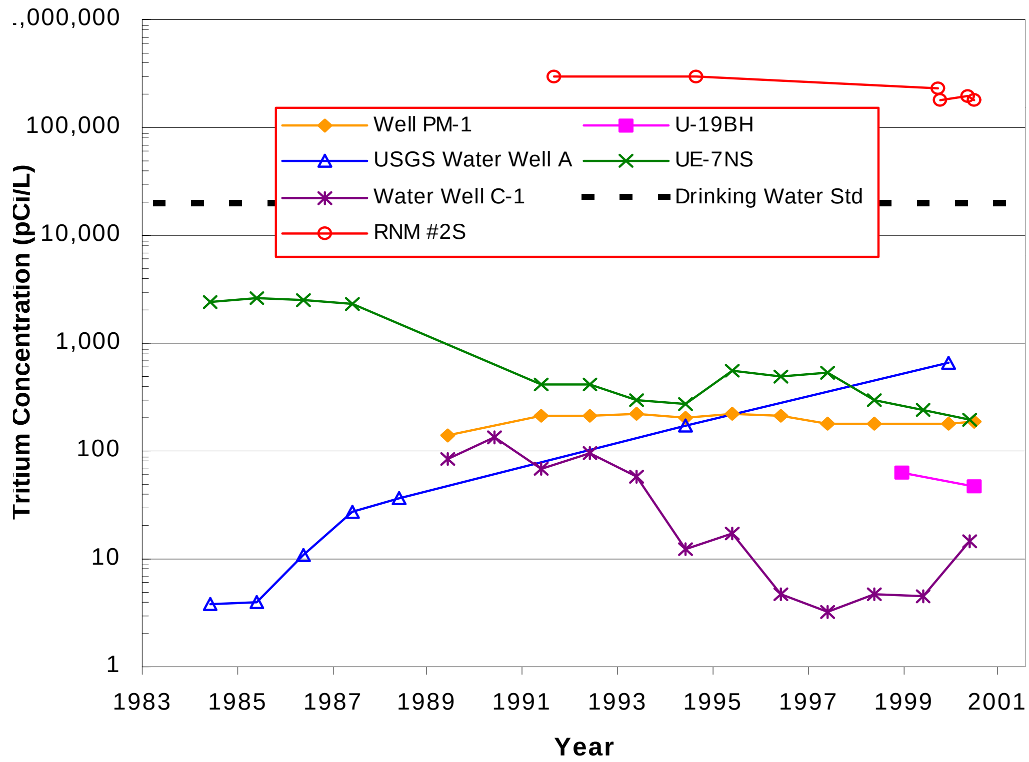


Figure 8.4 Wells with a History of Detectable Tritium

Onsite Monitoring Wells

Of the twenty-three onsite monitoring wells sampled in year 2000, only four had results above the MDC for tritium. These locations are RNM #2S, UE-7nS, U-19bh and PM-1 (see Figure 8.5). These locations are located within 1 km of underground nuclear tests.

Well RNMS #2s was constructed to investigate radionuclide migration from the CAMBRIC (emplacement hole U-5e) underground nuclear test conducted in Frenchman Flat and is located less than 70 m from the emplacement hole. This well has a history of tritium concentrations roughly ten times the regulatory standard and has been studied extensively by the Los Alamos National Laboratory (LANL) and Lawerence Livermore National laboratory (LLNL). Details of LANL's investigations can be found in the Laboratory and Field Studies Related to Radionuclide Migration Project publication series (e.g. LANL LA-13787-PR).

Well PM-1, located on Pahute Mesa, has a history of tritium concentrations near 200 pCi/L over the last ten years. Due to equipment limitations, samples have been collected from depths which are not open to the aquifer. This well has an unslotted casing from ground surface to a depth of 2,300 m and open hole from 2,300-2,356 m below ground surface. Sampling depths have historically ranged from 3-100 m below the static water level (~643 m below ground surface). The casing was perforated in some locations to squeeze cement into the annulus. Although these perforations are generally filled with cement and are therefore relatively impermeable, cracks or incomplete grouting may exist which permits water from the formation to enter the casing. Future sampling events will collect samples along the borehole profile to aid in determining where tritium is entering the casing.

Potential sources of the tritium detected in Well PM-1 include the FARM (U-20ab), GREELEY (U-20g), and KASSERI (U-20z) underground nuclear tests. The FARM test, although believed to be downgradient, is the closest test detonated near or below the water table to PM-1. The GREELEY and KASSERI tests were of relatively large magnitude and detonated 2,429 and 1,196 m, upgradient of PM-1, respectively.

Well UE-7nS was drilled 137 m from the BOURBON underground nuclear test (U-7n) conducted in Yucca Flat in 1967. This well was routinely sampled between 1978 and 1987 and again since 1992. In year 2000, approximately 240 pCi/L of tritium was detected in water samples from Well UE-7nS. This represents a decreasing trend in tritium concentrations, yet marks the second known site on the NTS where the regionally important carbonate aquifer has been impacted by radionuclides from nuclear testing (Smith *et al*., 1999). Well Ue-2CE is the first known location on the NTS where the regionally important carbonate aquifer has been impacted. This well is located less than 200 m from the NASH test (conducted in Yucca Flat in 1967) and is not currently configured for sampling.

U-19bh is an inventory emplacement borehole on Pahute Mesa, which is currently used for sampling. This location has a tritium concentration slightly above the MDC. The origin of the tritium is unclear. Investigations at this location suggest that the water in this borehole is from a perched aquifer (Brikowski *et al*., 1993). There were several nuclear detonations conducted near the U-19bh borehole; however, identifying the likely source of tritium is particularly difficult due to a lack of data regarding the perched system.

Water Well A, located in Yucca Flat, has a reported tritium concentration below the MDC for the year 2000 sample. This result is likely erroneous. This location has a history of rising tritium concentrations over the last six years and had a reported concentration of 668 pCi/L in 1999 (see Figure 8.4). Water Well A is completed in alluvium and located within 1 km of 14 underground nuclear tests, most of which appear to be upgradient of Well A. It is therefore not likely that the tritium concentration in Water Well A is now below the MDC. Additional quality control measures will be instituted for the next sampling event at this location to investigate the year 2000 result.

It is significant to note that radionuclide contamination has not been detected in well U-3cn #5. This well is completed in the regionally significant carbonate aquifer 60 m from the BILBY (U-3cn) test. BILBY was conducted in 1963 in a zeolitic volcanic tuff confining unit (see section 7.4) less than 120 m above the carbonate aquifer.

Figure 8.4 is a time series plot of tritium concentration for locations sampled in 2000 with a history of detectable tritium. Data presented in Figure 8.4 prior to 1999 for wells PM-1, Water Well A and UE-7nS are annual averages obtained from EPA. Figure 8.5 shows the locations of wells with detectable tritium from samples collected in the CY 2000. Results for all onsite monitoring well samples are presented in Table 8.2.

Offsite Locations

Thirty-eight offsite locations were sampled for tritium analyses in 2000. Three of these locations had results above the MDC but well below the regulatory standard (all results are less than 25 pCi/L). These locations are Spicer's Ranch spring, Ash-B piezometer #1, and Ponderosa Dairy Barn Well #2. The uncertainty of the Ash-B piezometer # 1 result encompasses the MDC. The Spicer's Ranch location sample is above the MDC; however, tritium was not detected in a sample replicate. The Longstreet Casino well value presented in Table 8.2 is the result determined by internal screening. The result received from the contracted laboratory was over 400 pCi/L and believed to be erroneous. The original sample collected and a resample aliquot were analyzed by internal personnel and found the concentration of tritium in the samples to be at instrument background levels.

All of the tritium detections from the offsite sampling locations were results reported from the new laboratory. It is likely that these results are the product of analytical error/uncertainty, as historical data and data collected by oversite organizations indicate these locations have not been impacted by tritium originating from the NTS. Future sampling events will include more quality control measures to assess analytical accuracy and precision. Table 8.2 presents results from all tritium analyses for CY 2000.

GROSS ALPHA

Onsite Supply Wells

Quarterly samples were collected from the supply wells for gross alpha analyses in CY 2000. All results were below the regulatory standard of 15 pCi/L, with the exception of the fourth quarter result from Water Well 5C, which slightly exceeded the standard with a value of 15.5 pCi/L. Safe Drinking Water Act (SDWA) regulations require annual averages to be below the standard; therefore, the well was within compliance for 2000 when the quarterly results were averaged. In addition to man-made radionuclides, many naturally occurring minerals/elements contribute to alpha radiation (e.g. minerals containing uranium). These elements are more abundant in volcanic source rocks and therefore wells producing water from these rocks will likely have relatively higher gross alpha values. Results of all gross alpha analyses for samples collected in 2000 are presented in Table 8.3.

Figure 8.6 shows the annual averages of gross alpha analyses for the supply wells from the past ten years. This figure illustrates that the regulatory standard for gross alpha has not been exceeded since 1991.

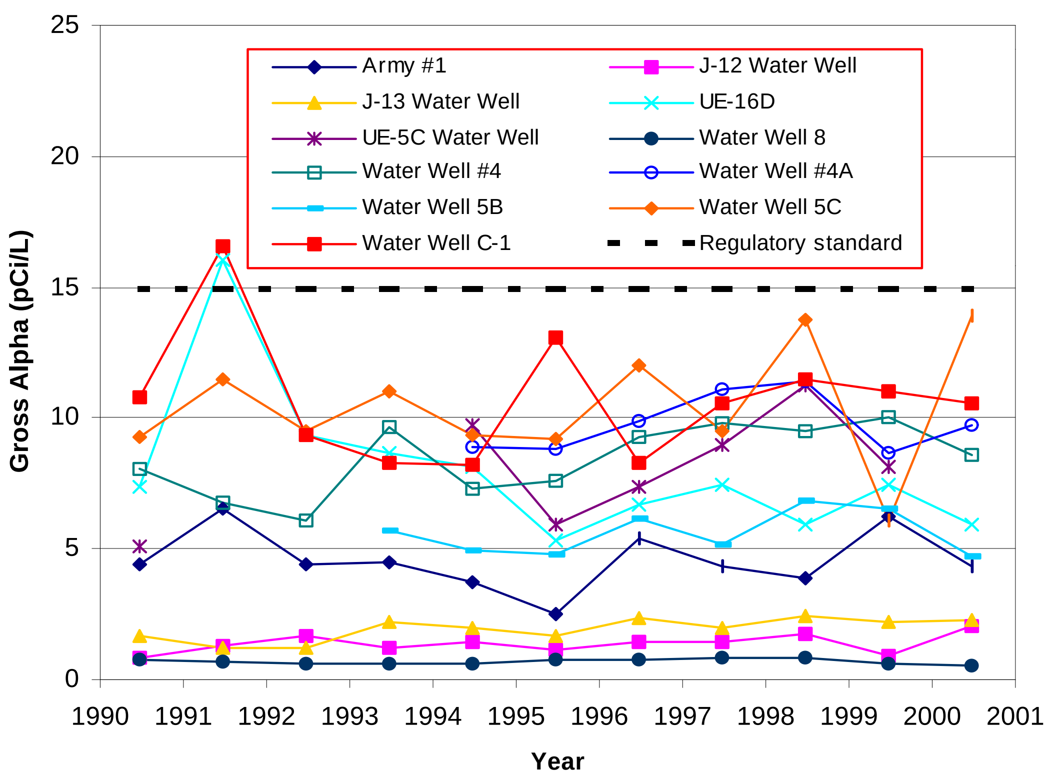


Figure 8.6 Annual Averages of Gross Alpha in Supply Wells

A statistical analysis was performed to evaluate the gross alpha data for trends. Using regression analysis, two locations (Water Wells J-12 and #4) were identified to have statistically significant increasing slopes (using a 5 percent significance level). Neither of these two trends were identified as being practically significant; however, the largest correlation coefficient (R^2) for these trend lines is less than 12 percent.

Drinking Water Endpoints

Samples for radioactivity analyses are no longer collected at drinking water endpoints (taps). Collection of these data has proven less useful than those collected at the wellhead due to the fact that several wells may be supplying the endpoint. For example, previous reports have presented gross alpha results from samples collected from the Areas 6 and 23 cafeteria taps (see Figure 8.7). These data give the appearance that the gross alpha levels have been rising at the Area 23 location. These data are somewhat misleading. Prior to 1995, roughly 75 percent of the water supplying the Area 23 cafeteria was from Army well #1; Well 5C provided the other 25 percent. From 1995 to 1996 Army well use was gradually reduced to a negligible amount due to elevated water hardness. Since 1996, the Area 23 cafeteria location has been supplied primarily by Wells 5B and 5C (~80 percent) with Wells 4 and 4A providing the balance (~20 percent). Army well #1 is completed in a carbonate aquifer, while Wells 5B and 5C produce water from the alluvial aquifer (composed of detritus derived from volcanic rocks), and Wells 4 and 4A produce water from volcanic aquifers. As pointed out in the previous section, volcanic rocks contain relatively higher quantities of natural alpha-yielding elements, which will likely produce higher concentrations of gross alpha radiation in water pulled from these formations. From inspection of Figure 8.6 and evaluation of the data, it is evident that the concentrations of gross alpha at the Area 23 cafeteria are higher than in previous years simply because the source of water supplying the endpoint has changed to wells that have slightly higher naturally occurring gross alpha concentrations than the previous combination of wells. Samples are now collected solely from the source wells to quantify concentrations of radioactive analytes entering the drinking water distribution system.

Onsite Monitoring Wells/Offsite Locations

During 2000, five onsite monitoring wells and thirty-seven offsite locations were sampled for gross alpha analyses. All samples were below the regulatory standard with the exception of offsite wells ER-OV-02 and ER-OV-03A, which are used solely as monitoring locations. These elevated gross alpha values may be a result of decay from naturally occurring uranium as well as local variations in mineralogy due to hydrothermal alteration of the volcanic host rock. Table 8.3 presents all gross alpha results for samples collected in 2000.

It should be noted that Nye County well (NC-EWDP-4PB) is not a RREMP well. This location was sampled at the request of NNSA/NV to confirm an anomalously high gross alpha result obtained by a local government agency. Gross alpha results obtained by BN were below the regulatory standard and confirmed the previous result as a false positive. Suspected causes for the erroneously high value are poor well development and inadequate purging prior to sample collection.

GROSS BETA

Onsite Supply Wells

Results for all gross beta analyses collected from the supply wells in 2000 were well below the drinking water standard of 50 pCi/L. Figure 8.8 is a plot of historical gross beta annual averages. A regression analysis was performed to evaluate the gross beta data for trends. One location

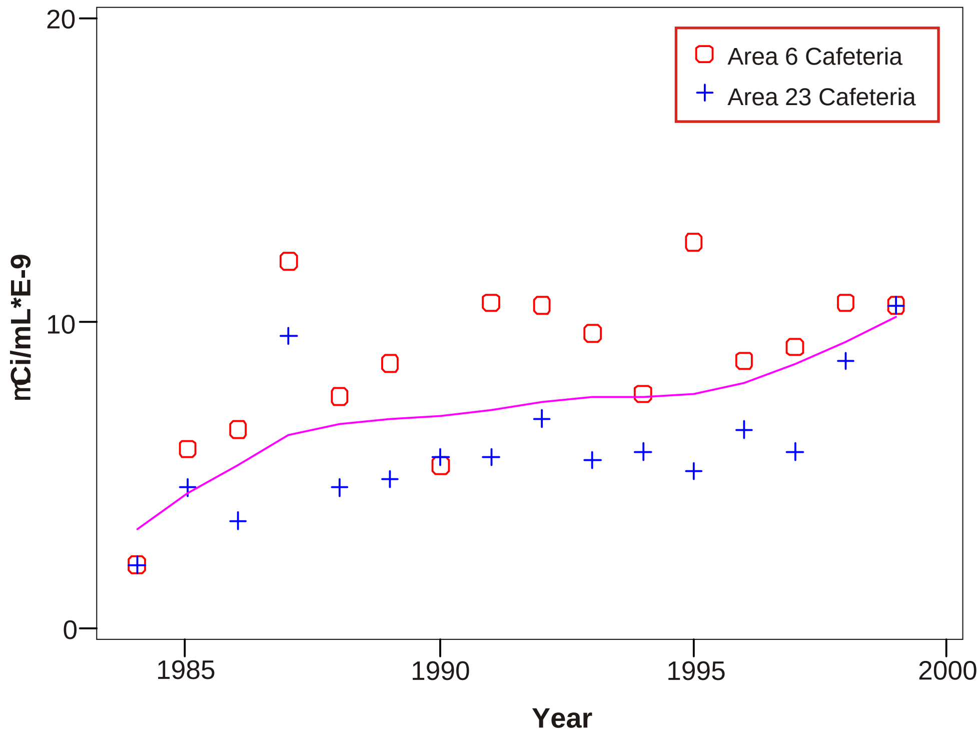


Figure 8.7 Historical Time Series for Gross Alpha in Tap Water

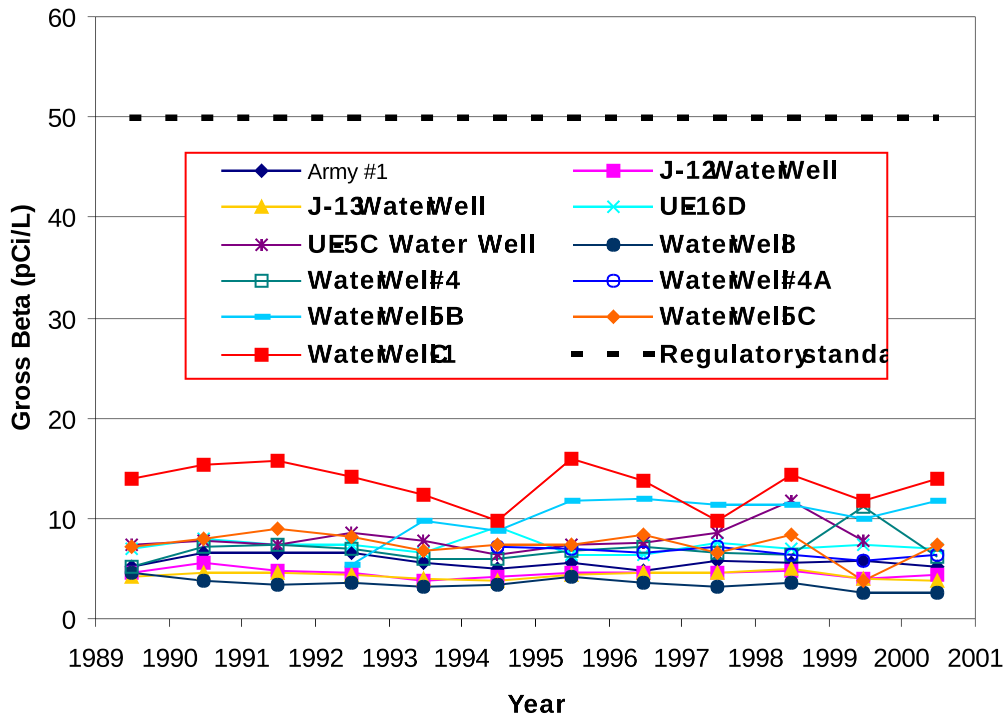


Figure 8.8 Annual Averages of Gross Beta in Supply Wells

(Water Well 5B) was identified as having a statistically significant increasing slope (using a 5 percent significance level). This trend has little practical significance; however, as the correlation coefficient (R^2) for this trend line is less than 20 percent. Additionally, the Well 5B location shows initial low values which have stabilized and remained relatively constant since 1995. Actual gross beta values for CY 2000 analyses are presented in Table 8.4.

Onsite Monitoring Wells/Offsite Locations

During 2000, samples were collected for gross beta analyses from five onsite monitoring wells and thirty-seven offsite locations. All results were below drinking water standards and are presented in Table 8.4.

GAMMA SPECTROSCOPY

Ten supply wells, five onsite monitoring locations and thirty-eight offsite locations were sampled for gamma-emitting radionuclides in 2000. There were no gamma-emitting radionuclides detected in any supply well or onsite location sampled. Ten offsite locations had detectable concentrations of radionuclides, results are presented in Table 8.5. All gamma results, when accounting for analytical uncertainty, were below MDCs with the exception of the Nye County well (NC-EWDP-4PB) and Peacock Ranch locations which had detections of the naturally-occurring ^{40}K, ^{214}Pb, and ^{214}Bi isotopes. The Nye County well is not in the RREMP and was sampled at the request of NNSA/NV as previously discussed.

RADIUM

During 2000, five onsite monitoring wells, twenty-five offsite locations and ten supply wells were sampled for radium analyses. All results from the onsite monitoring wells and offsite locations were below the drinking water standard of 5 pCi/L for the combined ^{226}Ra and ^{228}Ra concentrations. Quarterly samples were taken from the supply wells and the annually averaged results are well below the drinking water standard. The fourth quarter sample from Army Well #1 had a result of 5.97 pCi/L for ^{226}Ra and 2.0 pCi/L for ^{228}Ra. These values seem to be a result of analytical error as the gross alpha result from the same sample is 3.49 pCi/L and historic results for radium analyses at this location have been dominated by values well below the combined 5 pCi/L standard. Results from CY 2000 radium analyses are presented in Tables 8.6 and 8.7.

PLUTONIUM

Ten supply wells, four onsite monitoring locations and thirty-seven offsite locations were sampled for ^{238}Pu and $^{239+240}Pu$ in 2000. All plutonium results (±2 sigma uncertainty/error) were at or below the MDC and are presented in Tables 8.8 and 8.9.

STRONTIUM

During 2000, five onsite monitoring wells, thirty-seven offsite locations and ten supply wells were sampled for ^{90}Sr analyses. All results (±2 sigma uncertainty/error) were below the MDC with the exception of onsite well RNM#1 (5.8 pCi/L). RNM#1 is a post shot hole installed to investigate radionuclide migration from the CAMBRIC (emplacement hole U-5e) underground nuclear test. ^{90}Sr results for RNM #1 were below the drinking water standard of 8 pCi/L, even though it is located less than 150 m from U-5e. Results for CY 2000 ^{90}Sr analyses are presented in Table 8.10.

8.4 SUMMARY OF GROUNDWATER MONITORING

In 2000, over 60 groundwater monitoring locations were sampled for radioactivity. Of the over 60 locations sampled, there was only one location sampled which exceeded of the SDWA regulatory limit for the primary target analyte, tritium. This location is RNM #2S and is a post-shot hole located less than 70 m from the CAMBRIC underground nuclear test. Although some analytical data received in 2000 are of questionable quality, they are generally in good agreement with data collected by the oversight organization and indicate that radionuclides have traveled less than one mile from testing areas and in some locations, significantly less than one mile.

8.5 GROUNDWATER MONITORING OVERSIGHT ACTIVITIES

COMMUNITY ENVIRONMENTAL MONITORING PROGRAM - WATER MONITORING PROJECT

The Desert Research Institute (DRI) was tasked by the U. S. Department of Energy, during fiscal year 2000, to provide independent verification of the level of radioactivity within some of the offsite groundwater wells drilled to the south and west of the Nevada Test Site. Samples collected by DRI personnel provide not only an independent measure of the levels of radioactivity within these wells, but also a direct comparison to the results obtained by the RREMP.

The primary analyte for this project was tritium. Tritium is one of the most abundant radionuclides generated by an underground nuclear test, and since it is incorporated into the water molecule itself, it is also one of the most mobile. Samples from a few of the wells were analyzed for additional measures of radioactivity. The intent of the additional analyses was to provide a more comprehensive suite of radionuclides for a portion of the wells being monitored. As such, samples were collected for additional analyses from one third of all sample locations.

Sample Locations

Twenty-eight wells and one spring were sampled during the period of May 8 to October 11, 2000, utilizing a combination of bailers, pumps, windmills, or grab samples. Table 8.11 lists all of the wells, the date they were sampled, sampling methodology, and the analysis conducted. The locations of the wells and spring are also presented in Figure 8.3. Not all offsite RREMP groundwater sample locations were accessible to DRI. Replacement locations were sampled if possible.

Procedures and Quality Assurance

DRI utilized several methods to ensure that radiological results reported herein conform to current quality assurance protocols. This was achieved through the use of standard operating procedures, field quality assurance samples, and laboratory quality assurance procedures.

DRI standard operating procedures are detailed instructions that describe the method and materials, using step-by-step instructions, that are required to decontaminate and operate the sample equipment, collect field water quality samples, and protect the samples from tampering and environmental conditions that may alter their chemistry.

The second tier of quality assurance utilized on this project consisted of field quality assurance samples. The intent of these samples and procedures was to provide direct measures of the contribution of radioactive material that was derived from the bottles, sampling equipment, and the environment to the activity of tritium measured within the samples. In addition, duplicate samples were collected to establish a measure of the repeatability of the analysis. Field quality assurance samples were collected solely to support the interpretation of the tritium samples. Five samples (17 percent of the sample load) were collected for the purposes of meeting field quality assurance requirements. Laboratory quality assurance controls consisted of the utilization of published laboratory techniques for the analysis of each radionuclide, method blanks, laboratory control samples, and laboratory duplicates. The laboratory quality assurance samples provide a measure of the accuracy, and limit of detection of the reported results.

A comparison of laboratory quality assurance results to field quality assurance results indicated problems associated with the analyses determined by Severn Trent Laboratories. The analyses appeared to overestimate the quantity of tritium within field quality assurance samples and duplicate analyses from some of the wells differed by up to 111 pCi/L. In addition, the reported levels of tritium from several of the ER-OV wells significantly exceeded results previously obtained from these wells by BN and Lawrence Livermore National Laboratory. The problems associated with the results from the quality assurance samples and the consistently greater concentration reported for all of the wells (relative to previous analyses) inspired a low degree of confidence for this first set of analyses.

For this reason, samples from the wells with the highest reported quantities of tritium were resubmitted to a second laboratory (University of Waterloo) for analysis along with additional quality assurance samples. Results from the quality assurance samples associated with the second set of analyses allowed a high degree of confidence to be associated with them.

Tritium Results

The results of tritium analyses from Severn Trent, the University of Waterloo, and BN are presented in Table 8.12. Tritium activities reported by Severn Trent laboratories averaged 29 pCi/L and ranged from 5.3 to 142 pCi/L. All sample analyses were well below the safe drinking water limit of 20,000 pCi/L. Comparison of the results from Severn Trent to those from the University of Waterloo and BN indicates that in almost all cases the Severn Trent results exceeded the other results, typically by 5 to 15 pCi/L. However, Severn Trent Results from several of the wells (Ash B#1, TW-5, ER-OV-2, ER-OV-3a, ER-OV-4a, ER-OV-05, and ER-OV-6a) significantly exceeded the other analyses.

A second set of analyses, by the University of Waterloo on the same samples, directly refuted the results of Severn Trent. The results reported by the University of Waterloo were non-detects for tritium from all of the reanalyzed samples and for an additional sampling point within the Beatty water distribution system. Quality assurance samples associated with the University of Waterloo analyses were well within project requirements.

Comparison of the Severn Trent analyses to BN results shows that the Severn Trent analyses exceeded BN results in all but one case (Cooks Ranch Well #2). However, the low degree of confidence associated with these samples and the tendency of the Severn Trent analyses to overestimate the tritium concentration places considerable doubt that tritium was actually present in these wells at activities exceeding BN reported results. Comparison of the University of Waterloo results with the results from BN shows that both sets of analyses were below the limit of detection, with the exception of BN's analysis of Ash-B#1. The results, although not identical, are undifferentiable.

It is important to note that DRI quality assurance protocols were able to identify problems associated with the first laboratories analyses. This in turn led to the reanalysis of questionable samples so that major uncertainties associated with the first sample analyses were resolved.

Gross Alpha, Gross Beta, Gamma Spectrum and Plutonium Results

In addition to tritium, samples for gross alpha, gross beta, gamma spectroscopy, and plutonium analyses were collected at six locations (Coffers Ranch Windmill, ER-OV-1, ER-OV-2, ER-OV-3c, ER-OV-3c2, and ER-OV-6a). These samples were taken with the intent of providing a more comprehensive radiological analysis of a portion of the RREMP wells. The results of these analyses are presented in Table 8.13.

Gross beta analysis from the wells ranged from 4.8 to 36.2 pCi/L with a mean of 15.57 pCi/L and a standard deviation of 8.4 pCi/L. All of the analyses were below national drinking water standards. The gross alpha analysis ranged from below MDC to 37.1 pCi/L. The mean concentration was 14.31 pCi/L and the standard deviation was 10.8 pCi/L. Three wells, ER-OV-01, ER-OV-02, and ER-OV-3c2 exceeded the national drinking water standard of 15 pCi/L. The elevated alpha concentration may be due to the decay of natural uranium and its daughter products.

8.6 SUMMARY OF GROUNDWATER MONITORING OVERSIGHT ACTIVITIES

Twenty-eight wells and one spring were sampled during the period of May 8 to October 11, 2000. Tritium results from these wells indicated all analyses were well below the national drinking water standard. Initial results from all but one well exceeded CY 2000 BN results. Abnormalities associated with the quality assurance samples led to the reanalysis of the samples from the wells with the highest reported concentration. Quality assurance samples associated with the second set of analysis were acceptable and tritium was not detected in any of the samples. None of the wells contained plutonium isotopes, nor did any of the wells, with the exception of one sample from ER-OV-02, contain gamma-emitting radionuclides. The initial result from ER-OV-02 was contradicted by a sample collected 20 days later. All of the wells contained gross beta concentrations below the national drinking water standard. Three wells had gross alpha concentrations that exceeded the national drinking water standard.

8.7 VADOSE ZONE MONITORING

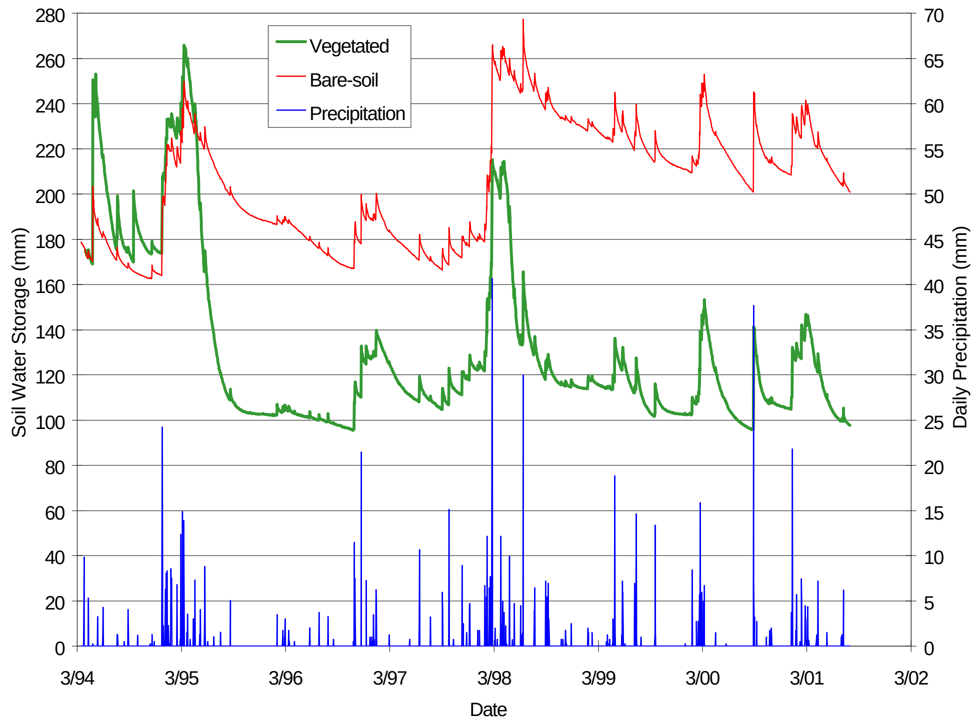
As explained in Chapter 4.0 of this report, the vadose zone is monitored at three general types of sites on the NTS: RWMSs, RCRA closure sites, and permitted sanitary landfills. Vadose zone monitoring is conducted at various locations in addition to, or in lieu of, groundwater monitoring for the purpose of protecting groundwater resources.

A vadose zone monitoring dataset has been collected for the past seven years at the Area 5 weighing lysimeter facility. This facility consists of two weighing lysimeters located about 400 m (1312 ft) southwest of the Area 5 RWMS. Each lysimeter consists of a steel box 2 m (6.6 ft) deep, filled with soil and having an area of 2 m x 4 m (6.6 ft x 13 ft). Each lysimeter is mounted on a sensitive scale, which is continuously monitored using an electronic loadcell. One lysimeter is vegetated with native plant species at the approximate density of the surrounding desert, and one lysimeter is kept bare to simulate the bare operational waste covers at the Area 5 RWMS. Each of the lysimeters is instrumented with soil water content (TDR) and soil water potential (HD) sensors at depths ranging from 10 to 170 cm (0.3 to 5.6 ft). The facility has been in continuous operation since March 1994, providing measurements of the near-surface water balance components including depths of infiltration, water content and water potential profiles, evapotranspiration, bare-soil evaporation, total soil water storage, and drainage. This facility has provided data to support the important assumption made in the Area 3 and Area 5 PAs of no downward movement of water beyond plant rooting depths. This facility has also provided data to justify other NTS closure covers (DOE, 2000c, d).

Total soil water storage is illustrated in Figure 8.9 for the period of March 30, 1994, through July 30, 2001. Daily precipitation totals are also illustrated in Figure 8.9. The soil water storage increases, early in the data record for the vegetated lysimeter, were due to irrigations to ensure that transplanted vegetation survived. Note the steep decrease in soil water storage in the vegetated lysimeter following high-rainfall periods. Also note that the vegetated lysimeter is considerably drier than the bare-soil lysimeter, despite the paucity of plants in the vegetated lysimeter (about 15 percent cover). Data from the vegetated weighing lysimeter indicate that rainwater rarely infiltrates past a depth of 1 m (3 ft) and is quickly returned to the atmosphere by plant transpiration, even during wet years. No drainage has ever been measured from the permeable bottoms of either lysimeter to date. However, volumetric water content at a depth of 170 cm (5.6 ft) in the bare-soil lysimeter has increased from about 9 to 14 percent in the past seven years.

In addition to the weighing lysimeter facility, a new drainage lysimeter facility was recently installed next to the U-3ax/bl disposal unit at the Area 3 RWMS, and vadose zone monitoring of waste cell covers and floors using automated systems has been conducted at the Area 5 RWMS since late 1998. Soil water content at various depths with time is illustrated in Figure 8.10 for an automated waste cover monitoring system on the cover of Pit 3 at the Area 5 RWMS. Note the depth of infiltration has not exceeded 90 cm (3 ft) before that water was returned to the atmosphere by evaporation. Slight fluxuations in water contents are seen at greater depths, but these are the result of water vapor flow rather than liquid wetting fronts.

For further details on, and data from, the RWMS VZM program, refer to BN (2001b).



Vegetated
Bare-soil
Precipitation
Soil Water Storage (mm)
Daily Precipitation (mm)
Date
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
70
65
60
55
50
45
40
35
30
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3/02

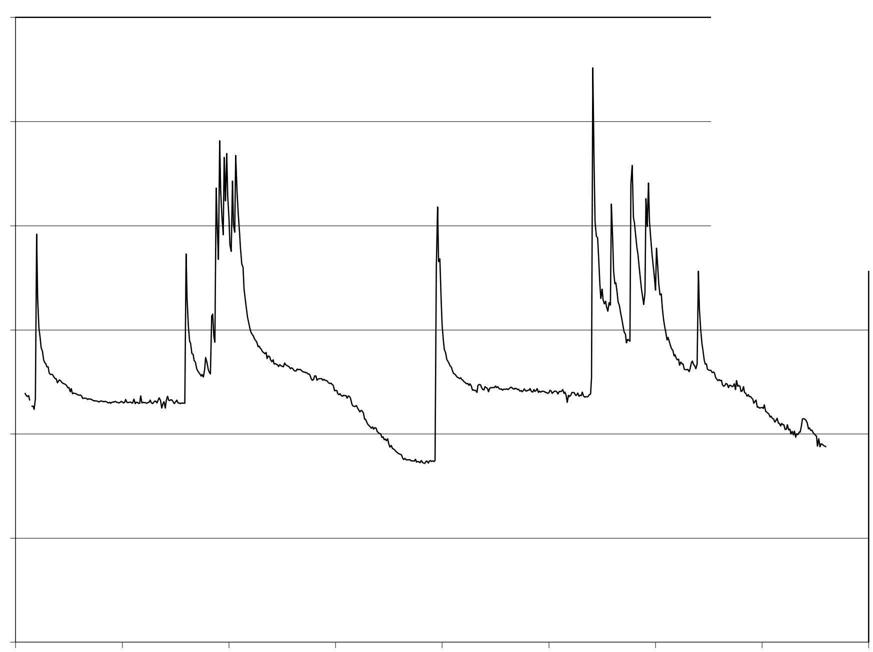

Table 8.1 Sampling and Analysis Schedule for RREMP Groundwater Monitoring

Sample Location Type		Analysis	Sample Frequency	Regulatory Driver
Onsite Locations	Potable water supply well within CAU	Ie & II	Quarterly	40 CFR 61 and DOE Order 5400
		III & IV	Annually	“
	Other potable water supply well	I & II	Quarterly	DOE Order 5400 Series
		III & IV	Annually	“
	CAU non-potable water supply well	Ie	Quarterly	DOE Order 5400 Series
		II, III, & IV	Annually	“
	Other non-potable water supply well	I	Semiannually	DOE Order 5400 Series
		II, III, & IV	Biennially	“
	Monitoring Well (Non-water supply)	I	Annually	DOE Order 5400 Series
		II, III, & IV	Biennially	“
	Source Characterization Well[(a)]	I, II, III, & IV	Biennially[(b)]	DOE Order 5400 Series
	New Wells	Ie, II, III, & IV	Quarterly[(c)]	DOE Order 5400 Series
	Group A locations (Oasis Valley and vicinity)	Ie, IIg	Quarterly	40 CFR 61 and DOE Order 5400
		II, III+	Annually	“
Offsite Locations[(d)]	Group B locations (more distant)	I, IIg	Semiannually	DOE Order 5400 Series
	Group C locations (most distant)	I, IIg	Annually	DOE Order 5400 Series
	New locations	Ie, II, III+, IV	First sample	40 CFR 61 and DOE Order 5400

(a) Source Characterization Wells are currently known as the Hot Well Network. Additional sampling parameters may be specified for each hot well.
(b) Biennial frequency can be modified for well-specific sampling program.
(c) After four quarterly samples are acquired, sampling parameters and frequency will be based on the well type.
(d) Offsite locations include both drilled wells and natural springs.

Note: All parameters and frequencies of analysis are subject to revision after data are acquired and reviewed, if justified.
Corrective Action Units (CAUs) are as defined by Underground Testing Area (UGTA) Project (IT, 1996c).

Type I   Analysis include Standard Tritium; at select wells enriched tritium analysis (Type Ie) will be performed.
Type II Analysis include Gross Alpha and Gross Beta. For drinking water wells, also includes Ra-226 & 228 analyses. Type IIg analysis includes only Gamma emitters.
Type III Analysis include Gamma emitters, Plutonium. Type III+ analysis includes Type III plus Sr-90.
Type IV Analysis include pH, Specific Conductivity, Temperature, Principal Cations/Anions, Total Dissolved Solids, Alkalinity, and Bicarbonate.

Table 8.2 Summary of Tritium Results - 2000

Area	Location	Sample Type	Date Sampled	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Supply Wells							
5	Water Well 5B	(a)	19-Jun-00	-0.37	9.43	5.65	pump
5	Water Well 5B	(b)	19-Jun-00	3.08	11.50	6.93	pump
5	Water Well 5B	(a)	25-Oct-00	4.89	12.40	7.30	pump
5	Water Well 5C	(a)	26-Jan-00	-3.34	10.20	6.11	pump
5	Water Well 5C	(a)	19-Apr-00	4.54	11.50	6.99	pump
5	Water Well 5C	(a)	19-Jun-00	-1.16	9.61	5.77	pump
5	Water Well 5C	(a)	25-Oct-00	2.70	11.30	6.70	pump
6	Water Well #4	(a)	23-Mar-00	-1.44	11.30	6.81	pump
6	Water Well #4	(a)	19-Apr-00	0.44	10.30	6.22	pump
6	Water Well #4	(a)	19-Jul-00	3.29	8.98	5.46	pump
6	Water Well #4	(a)	25-Oct-00	19.50	11.30	7.00	pump
6	Water Well #4A	(a)	26-Jan-00	-3.87	10.70	6.39	pump
6	Water Well #4A	(a)	19-Apr-00	0.17	11.00	6.66	pump
6	Water Well #4A	(a)	19-Jul-00	-0.40	9.31	5.59	pump
6	Water Well #4A	(a)	25-Oct-00	14.10	11.30	6.90	pump
6	Water Well C-1	(a)	26-Jan-00	27.40	9.94	6.33	pump
6	Water Well C-1	(a)	19-Jul-00	2.24	10.90	6.56	pump
6	Water Well C-1	(a)	25-Oct-00	15.50	13.90	8.40	pump
16	UE-16d Eleana Water Well	(a)	26-Jan-00	-5.26	8.96	5.31	pump
16	UE-16d Eleana Water Well	(a)	19-Apr-00	-3.83	10.00	5.97	pump
16	UE-16d Eleana Water Well	(a)	19-Jul-00	-3.33	10.10	6.03	pump
16	UE-16d Eleana Water Well	(a)	25-Oct-00	5.90	9.60	5.70	pump
18	Water Well 8	(a)	26-Jan-00	-6.56	11.50	6.82	pump
18	Water Well 8	(a)	19-Apr-00	0.53	11.40	6.82	pump
18	Water Well 8	(a)	19-Jul-00	-3.69	11.00	6.57	pump
18	Water Well 8	(a)	25-Oct-00	9.20	13.20	7.90	pump
18	Water Well 8	(b)	25-Oct-00	4.40	11.60	6.90	pump
22	Army #1 Water Well	(a)	26-Jan-00	-3.06	9.59	5.72	pump
22	Army #1 Water Well	(a)	19-Apr-00	-4.91	9.91	5.89	pump
22	Army #1 Water Well	(a)	19-Jul-00	-1.48	9.49	5.70	pump
22	Army #1 Water Well	(a)	24-Oct-00	-2.50	10.70	6.20	pump
25	J-12 Water Well	(a)	26-Jan-00	-1.02	11.10	6.64	pump
25	J-12 Water Well	(a)	19-Apr-00	4.92	10.60	6.45	pump
25	J-12 Water Well	(b)	19-Apr-00	-2.23	11.60	6.98	pump
25	J-12 Water Well	(a)	25-Jul-00	-3.72	9.95	5.95	pump
25	J-12 Water Well	(b)	25-Jul-00	3.96	21.20	12.80	pump
25	J-12 Water Well	(a)	24-Oct-00	32.70	13.50	8.50	pump
25	J-13 Water Well	(a)	26-Jan-00	-2.05	9.38	5.60	pump
25	J-13 Water Well	(a)	25-Jul-00	0.80	8.90	5.36	pump
25	J-13 Water Well	(a)	24-Oct-00	21.40	11.20	7.00	pump

(a) Normal sample.

(b) Field duplicate.

(c) Result is from internal screening.

Table 8.2 (Summary of Tritium Results - 2000, cont.)

Area Location	Sample Type	Date Sampled	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Monitoring						
1 UE-1q	(a)	17-Feb-00	-1.34	10.2	6.12	bailer
2 Water Well 2	(a)	08-Jun-00	-2.83	13	7.78	bailer
2 Water Well 2	(a)	08-Jun-00	0.84	11.4	6.86	bailer
3 ER-3-2	(a)	15-Jun-00	2.04	9.92	6	bailer
3 ER-3-2	(a)	15-Jun-00	-2.55	11.3	6.78	bailer
3 U-3cn #5	(a)	19-Jul-00	1.19	10.9	6.58	pump
3 U-3cn #5	(b)	19-Jul-00	2.07	9.49	5.73	pump
3 USGS Water Well A	(a)	17-Feb-00	-35.40	9.89	5.49	bailer
4 UE-4t	(a)	08-Jun-00	-2.21	10.4	6.19	bailer
4 UE-4t	(a)	08-Jun-00	1.14	8.4	5.06	bailer
4 USGS Test Well D	(a)	17-Feb-00	2.86	10.7	6.49	bailer
5 RNM #1	(a)	28-Jun-00	424.00	514	317	pump
5 RNM #1	(b)	28-Jun-00	255.00	514	311	pump
5 RNM #2S	(a)	17-May-00	195,000	1570	6220	pump
5 RNM #2S	(a)	13-Jun-00	194,000	5.12E+0	1.77E+0	pump
5 RNM #2S	(a)	29-Jun-00	178,000	2130	5910	pump
5 UE-5c Water Well	(a)	19-Apr-00	2.84	10.1	6.11	pump
5 UE-5c Water Well	(a)	19-Jul-00	6.79	20.3	12.3	pump
5 UE5PW-1	(a)	26-Apr-00	-3.49	10.2	6.07	pump
5 UE5PW-1	(b)	26-Apr-00	-1.62	11.4	6.82	pump
5 UE5PW-1	(a)	09-Aug-00	-2.50	10.9	6.5	pump
5 UE5PW-1	(b)	09-Aug-00	-2.55	11.3	6.76	pump
5 UE5PW-2	(b)	26-Apr-00	1.30	10.6	6.37	pump
5 UE5PW-2	(a)	26-Apr-00	1.03	10.3	6.2	pump
5 UE5PW-2	(a)	09-Aug-00	5.20	10.2	6.19	pump
5 UE5PW-2	(b)	09-Aug-00	8.74	10.2	6.25	pump
5 UE5PW-3	(b)	26-Apr-00	0.28	12.2	7.33	pump
5 UE5PW-3	(a)	26-Apr-00	-0.44	10.4	6.26	pump
5 UE5PW-3	(a)	09-Aug-00	6.41	12.9	7.82	pump
5 UE5PW-3	(b)	09-Aug-00	2.28	9.3	5.61	pump
6 ER-6-1	(a)	15-Jun-00	0.38	8.95	5.39	bailer
6 ER-6-1	(b)	15-Jun-00	-4.36	22.9	13.7	bailer
6 ER-6-1	(a)	15-Jun-00	1.17	10.8	6.49	bailer
6 ER-6-1	(a)	15-Jun-00	-1.03	10.6	6.37	bailer
7 UE-7nS	(a)	07-Jun-00	195.00	10.4	6.49	bailer
17 USGS HTH #1	(b)	12-Jul-00	1.16	10.6	6.41	bailer
17 USGS HTH #1	(a)	12-Jul-00	2.25	9.97	6.03	bailer
17 USGS HTH #1	(a)	12-Jul-00	-3.37	11.9	7.08	bailer
17 USGS HTH #1	(a)	12-Jul-00	1.43	10.2	6.15	bailer
17 USGS HTH #1	(a)	12-Jul-00	1.90	11.6	7.01	bailer
17 USGS HTH #1	(a)	12-Jul-00	3.84	9.75	5.91	bailer
18 UE-18r	(a)	13-Jul-00	-0.62	9.41	5.65	bailer
18 UE-18r	(a)	13-Jul-00	-0.80	9.41	5.65	bailer
18 UE-18r	(b)	13-Jul-00	-0.44	7.99	4.78	bailer
19 ER-19-1	(a)	29-Jun-00	3.39	12.5	7.56	bailer
19 ER-19-1	(a)	29-Jun-00	-4.69	12.2	7.27	bailer
19 U-19bh	(a)	05-Jul-00	48.00	9.08	6.05	bailer
20 ER-20-1	(a)	05-Jul-00	0.75	9.14	5.51	bailer
20 ER-20-2 #1	(a)	06-Jul-00	-2.60	9.03	5.41	bailer
20 Well PM-1	(a)	29-Jun-00	192.00	11.3	8.93	bailer
20 Well PM-1	(b)	29-Jun-00	176.00	12.3	9.36	bailer
23 SM-23-1	(a)	13-Mar-00	-245.00	505	294	pump

(a) Normal sample.

(b) Field duplicate.

(c) Result is from internal screening.

Table 8.2 (Summary of Tritium Results - 2000, cont.)

Area	Location	Sample Type	Date Sampled	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Offsite Wells and Springs							
95	Amargosa Valley RV Park	(a)	14-Nov-00	1.40	11.10	6.60	pump
95	Ash-B Piezom #1	(a)	09-Nov-00	16.40	14.00	7.80	bailer
95	Ash-B Piezom #2	(a)	14-Nov-00	-8.60	11.10	6.40	bailer
95	Ash-B Piezom #2	(b)	14-Nov-00	-4.00	11.80	6.80	bailer
95	Barn Well #2-Ponderosa Dairy	(a)	06-Dec-00	19.30	11.40	7.00	pump
95	Beatty Water and Sewer	(a)	04-Dec-00	3.30	13.20	7.80	pump
95	Beatty Water and Sewer	(b)	04-Dec-00	10.20	13.40	8.00	pump
95	Big Springs	(a)	16-Jun-00	-9.50	13.50	8.01	grab
95	Big Springs	(a)	06-Nov-00	-5.50	12.60	7.40	grab
95	Cind-R-Lite Mine	(a)	15-Nov-00	-1.60	12.40	7.20	pump
95	Cook's Ranch Well #2	(a)	05-Dec-00	9.50	11.30	6.80	pump
95	Crystal Pool	(a)	16-Jun-00	-0.66	12.10	7.31	grab
95	Crystal Pool	(a)	06-Nov-00	-8.70	10.30	5.90	grab
95	Crystal Trailer Park	(a)	06-Dec-00	-7.90	11.60	6.70	pump
95	Crystal Trailer Park	(b)	06-Dec-00	-11.60	11.70	6.60	pump
95	De Lee Ranch	(a)	05-Dec-00	3.60	7.70	7.70	pump
95	De Lee Ranch	(b)	05-Dec-00	4.10	7.90	13.40	pump
95	ER-OV-01	(a)	09-May-00	-1.96	10.4	6.23	bailer
95	ER-OV-01	(b)	09-May-00	1.07	11.1	6.7	bailer
95	ER-OV-01	(a)	06-Nov-00	-4.40	11	6.3	bailer
95	ER-OV-02	(a)	11-May-00	-7.71	11.3	6.67	bailer
95	ER-OV-02	(a)	07-Nov-00	-4.00	18	10.6	bailer
95	ER-OV-03A	(a)	07-Nov-00	-6.20	10.8	6.3	bailer
95	ER-OV-03A3	(a)	07-Nov-00	-5.60	11.1	6.4	bailer
95	ER-OV-03C	(a)	09-May-00	-5.99	9.26	5.49	bailer
95	ER-OV-03C	(a)	08-Nov-00	-3.20	11.7	6.8	bailer
95	ER-OV-03C2	(a)	09-May-00	-6.71	9.79	5.8	bailer
95	ER-OV-03C2	(a)	08-Nov-00	-6.60	10.8	6.2	bailer
95	ER-OV-03C2	(b)	08-Nov-00	-5.90	11.1	6.4	bailer
95	ER-OV-04A	(a)	08-Nov-00	-3.10	10.8	6.3	bailer
95	ER-OV-04A	(b)	08-Nov-00	-8.80	11	6.3	bailer
95	ER-OV-05	(a)	08-Nov-00	-9.80	11.5	6.6	bailer
95	ER-OV-06A	(a)	09-May-00	0.45	10.5	6.33	bailer
95	ER-OV-06A	(b)	09-May-00	-4.34	11.5	6.86	bailer
95	ER-OV-06A	(a)	06-Nov-00	-8.50	11.7	6.7	bailer
95	Fairbanks Spring	(a)	16-Jun-00	-2.57	11.80	7.07	grab
95	Fairbanks Spring	(a)	06-Nov-00	-7.30	9.40	5.40	grab
95	Fire Hall #2 Well	(a)	05-Dec-00	-7.90	11.10	6.30	pump
95	Last Trail Ranch	(a)	05-Dec-00	-7.00	10.70	6.20	pump
95	Longstreet Casino Well #1	(a)	15-Nov-00	0.20(c)	105.0	63.5	pump
95	Longstreet Spring	(a)	16-Jun-00	-1.81	10.60	6.35	grab

(a) Normal sample.
(b) Field duplicate.
(c) Result is from internal screening.

Table 8.2 (Summary of Tritium Results - 2000, cont.)

Area Location	Sample Type	Date Sampled	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Offsite Wells and Springs, cont.						
95 Longstreet Spring	(b)	06-Nov-00	-6.80	11.10	6.40	grab
95 Longstreet Spring	(a)	06-Nov-00	-4.20	10.70	6.20	grab
95 Nye County Well	(b)	02-Mar-00	-0.04	10.60	6.38	pump
95 Nye County Well	(b)	02-Mar-00	128.00	526.00	316.00	pump
95 Nye County Well	(a)	02-Mar-00	141.00	526.00	316.00	pump
95 Nye County Well	(a)	02-Mar-00	3.16	9.96	6.04	pump
95 Peacock Ranch	(a)	07-Nov-00	-2.50	10.20	5.90	grab
95 Peacock Ranch	(b)	07-Nov-00	0.57	9.20	5.40	grab
95 PM-3	(b)	10-Nov-00	-0.25	9.90	5.78	bailer
95 PM-3	(a)	10-Nov-00	-4.69	9.70	5.60	bailer
95 PM-3	(a)	10-Nov-00	1.28	10.00	5.90	bailer
95 Revert Spring	(a)	07-Nov-00	-2.10	10.00	5.90	grab
95 Road D Well	(a)	09-Nov-00	0.26	10.10	5.90	bailer
95 Road D Well	(b)	09-Nov-00	3.40	10.60	6.20	bailer
95 Roger Bright Ranch	(a)	05-Dec-00	-4.70	10.70	6.20	pump
95 School Well	(a)	04-Dec-00	-7.00	11.00	6.30	pump
95 Sod Farm	(a)	06-Dec-00	-6.20	11.50	6.60	pump
95 Spicer Ranch	(a)	04-Dec-00	-15.20	14.30	8.20	grab
95 Spicer Ranch	(b)	04-Dec-00	24.40	11.80	7.40	grab
95 Tolicha Peak	(a)	21-Nov-00	5.60	10.60	6.30	pump
95 Tolicha Peak	(b)	21-Nov-00	3.80	9.00	5.30	pump
95 TW-5	(a)	08-May-00	-2.68	11.20	6.67	bailer
95 U.S. Ecology	(a)	15-Nov-00	0.40	10.70	6.30	pump
95 U.S. Ecology	(b)	15-Nov-00	-0.30	10.40	6.10	pump
95 USW H-1	(a)	21-Jun-00	1.64	12.50	7.49	bailer
95 USW H-1	(a)	22-Jun-00	-0.57	13.40	8.07	bailer
95 USW H-1	(a)	22-Jun-00	2.46	11.90	7.23	bailer
95 USW H-1	(b)	22-Jun-00	2.55	12.60	7.62	bailer

(a) Normal sample.

(b) Field duplicate.

(c) Result is from internal screening.

Table 8.3 Summary of Gross Alpha Results - 2000

Area	Location	Sample Type	Date Sampled	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Supply Wells							
5	Water Well 5B	(a)	19-Jul-00	5.33	1.63	1.41	pump
5	Water Well 5B	(b)	19-Jul-00	6.15	1.72	1.53	pump
5	Water Well 5B	(a)	25-Oct-00	3.72	0.54	3.71	pump
5	Water Well 5C	(a)	26-Jan-00	14.20	1.56	2.03	pump
5	Water Well 5C	(a)	26-Jan-00	13.60	1.60	2.03	pump
5	Water Well 5C	(a)	19-Apr-00	10.70	1.70	1.86	pump
5	Water Well 5C	(a)	19-Jul-00	7.88	1.75	1.67	pump
5	Water Well 5C	(a)	25-Oct-00	15.50	0.77	4.67	pump
6	Water Well #4	(a)	23-Mar-00	8.57	1.49	1.59	pump
6	Water Well #4	(a)	23-Mar-00	10.50	1.48	1.71	pump
6	Water Well #4	(a)	19-Apr-00	10.80	1.55	1.77	pump
6	Water Well #4	(a)	19-Jul-00	9.01	1.59	1.65	pump
6	Water Well #4	(a)	25-Oct-00	5.02	0.42	2.33	pump
6	Water Well #4A	(a)	26-Jan-00	8.49	1.44	1.58	pump
6	Water Well #4A	(a)	26-Jan-00	10.10	1.44	1.69	pump
6	Water Well #4A	(a)	19-Apr-00	12.60	1.56	1.88	pump
6	Water Well #4A	(a)	19-Jul-00	9.24	1.55	1.64	pump
6	Water Well #4A	(a)	25-Oct-00	7.71	0.64	3.32	pump
6	Water Well C-1	(a)	26-Jan-00	14.20	3.08	3.08	pump
6	Water Well C-1	(a)	26-Jan-00	14.50	3.01	3.07	pump
6	Water Well C-1	(a)	19-Jul-00	7.71	1.90	1.75	pump
6	Water Well C-1	(a)	25-Oct-00	9.76	1.52	4.41	pump
16	UE-16d Eleana Water Well	(a)	26-Jan-00	8.01	1.71	1.72	pump
16	UE-16d Eleana Water Well	(a)	19-Apr-00	6.29	1.74	1.57	pump
16	UE-16d Eleana Water Well	(a)	19-Jul-00	4.19	1.81	1.42	pump
16	UE-16d Eleana Water Well	(a)	25-Oct-00	5.24	1.12	2.36	pump
18	Water Well 8	(a)	26-Jan-00	0.97	1.00	0.67	pump
18	Water Well 8	(a)	26-Jan-00	0.57	0.92	0.57	pump
18	Water Well 8	(a)	19-Apr-00	1.12	0.89	0.61	pump
18	Water Well 8	(a)	19-Jul-00	-0.03	0.85	0.46	pump
18	Water Well 8	(a)	25-Oct-00	0.35	0.43	0.31	pump
18	Water Well 8	(b)	25-Oct-00	0.48	0.39	0.30	pump
22	Army #1 Water Well	(a)	26-Jan-00	5.77	1.53	1.43	pump
22	Army #1 Water Well	(a)	26-Jan-00	4.19	1.50	1.27	pump
22	Army #1 Water Well	(a)	19-Apr-00	5.41	1.64	1.44	pump
22	Army #1 Water Well	(a)	19-Jul-00	3.48	1.65	1.26	pump
22	Army #1 Water Well	(a)	24-Oct-00	3.49	0.74	1.11	pump
25	J-12 Water Well	(a)	26-Jan-00	3.46	1.33	1.11	pump
25	J-12 Water Well	(a)	19-Apr-00	2.08	1.40	1.00	pump
25	J-12 Water Well	(b)	19-Apr-00	2.57	1.29	0.98	pump
25	J-12 Water Well	(a)	25-Jul-00	1.56	1.43	0.96	pump
25	J-12 Water Well	(a)	24-Oct-00	1.01	0.43	0.38	pump
25	J-13 Water Well	(a)	26-Jan-00	3.72	1.33	1.13	pump
25	J-13 Water Well	(a)	25-Jul-00	2.32	1.45	1.04	pump
25	J-13 Water Well	(a)	24-Oct-00	0.91	0.23	0.85	pump
Onsite Monitoring Wells							
3	U-3cn #5	(a)	19-Jul-00	4.53	1.75	1.41	pump
5	RNM #1	(a)	28-Jun-00	7.51	1.55	1.52	pump
7	UE7nS	(a)	07-Jun-00	1.29	1.72	1.09	bailer
17	USGS HTH #1	(a)	12-Jul-00	11.60	1.64	1.84	bailer
23	SM-23-1	(a)	13-Mar-00	3.58	1.68	1.31	pump

(a) Normal sample.
(b) Field duplicate.

Table 8.3 (Summary of Gross Alpha Results - 2000, cont.)

Area Location	Sample Type	Date Sampled	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Offsite Wells and Springs						
95 Amargosa Valley RV Park	(a)	14-Nov-00	0.78	0.50	0.50	pump
95 Ash-B Piezom #1	(a)	09-Nov-00	0.62	0.71	0.71	bailer
95 Ash-B Piezom #2	(a)	14-Nov-00	0.72	0.73	0.73	bailer
95 Barn Well #2-Ponderosa Dairy	(a)	06-Dec-00	2.69	0.63	0.63	pump
95 Beatty Water and Sewer	(a)	04-Dec-00	11.50	1.82	1.82	pump
95 Big Springs	(a)	16-Jun-00	4.32	2.16	2.16	grab
95 Big Springs	(a)	06-Nov-00	3.86	0.80	0.80	grab
95 Cind-R-Lite Mine	(a)	15-Nov-00	1.83	0.40	0.40	pump
95 Cook's Ranch Well #2	(a)	05-Dec-00	0.28	2.71	2.71	pump
95 Crystal Pool	(a)	16-Jun-00	4.68	2.22	2.22	grab
95 Crystal Pool	(a)	06-Nov-00	4.95	0.90	0.90	grab
95 Crystal Trailer Park	(a)	06-Dec-00	3.78	1.59	1.59	pump
95 De Lee Ranch	(a)	05-Dec-00	1.65	0.45	0.45	pump
95 ER-OV-01	(a)	06-Nov-00	14.80	0.89	0.89	bailer
95 ER-OV-02	(a)	07-Nov-00	31.00	0.90	0.90	bailer
95 ER-OV-03A	(a)	07-Nov-00	20.30	1.19	1.19	bailer
95 ER-OV-03A3	(a)	07-Nov-00	9.86	0.97	0.97	bailer
95 ER-OV-03C	(a)	08-Nov-00	6.88	0.73	0.73	bailer
95 ER-OV-03C2	(a)	08-Nov-00	5.94	0.69	0.69	bailer
95 ER-OV-04A	(a)	08-Nov-00	3.93	0.58	0.58	bailer
95 ER-OV-05	(a)	08-Nov-00	3.15	1.34	1.34	bailer
95 ER-OV-06A	(a)	06-Nov-00	7.42	1.41	1.41	bailer
95 Fairbanks Spring	(a)	16-Jun-00	3.72	2.21	2.21	grab
95 Fairbanks Spring	(a)	06-Nov-00	2.01	1.21	1.21	grab
95 Fire Hall #2 Well	(a)	05-Dec-00	2.75	0.84	0.84	pump
95 Last Trail Ranch	(a)	05-Dec-00	11.80	2.82	2.82	pump
95 Longstreet Casino Well #1	(a)	15-Nov-00	1.31	0.96	0.96	pump
95 Longstreet Spring	(a)	16-Jun-00	3.80	2.13	2.13	grab
95 Longstreet Spring	(a)	06-Nov-00	5.26	0.68	0.68	grab
95 NYE County Well	(b)	02-Mar-00	6.77	1.21	1.21	pump
95 NYE County Well	(a)	02-Mar-00	7.03	1.17	1.17	pump
95 Peacock Ranch	(a)	07-Nov-00	4.72	1.93	1.93	grab
95 PM-3	(a)	10-Nov-00	1.21	0.81	0.81	bailer
95 PM-3	(a)	10-Nov-00	0.34	0.46	0.46	bailer
95 Revert Spring	(a)	07-Nov-00	4.66	0.55	0.55	grab
95 Road D Well	(a)	09-Nov-00	3.72	0.77	0.77	bailer
95 Roger Bright Ranch	(a)	05-Dec-00	6.28	1.78	1.78	pump
95 School Well	(a)	04-Dec-00	1.82	0.54	0.54	pump
95 Sod Farm	(a)	06-Dec-00	1.11	0.32	0.32	pump
95 Spicer Ranch	(a)	07-Nov-00	9.16	0.578	3.8	grab
95 Tolicha Peak	(a)	21-Nov-00	3.38	2.05	2.05	pump
95 TW-5	(a)	08-May-00	12.40	3.17	3.17	bailer
95 U.S. Ecology	(a)	15-Nov-00	7.13	1.29	1.29	pump
95 USW H-1	(a)	22-Jun-00	4.40	1.33	1.33	bailer
95 USW H-1	(a)	22-Jun-00	3.68	8.17	8.17	bailer
95 USW H-1	(a)	21-Jun-00	-0.30	4.36	4.36	bailer

(a) Normal sample.

(b) Field duplicate.

Table 8.4 Summary of Gross Beta Results - 2000

Area Location	Sample Type	Date Sampled	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Supply Wells						
5 Water Well 5B	(a)	19-Jul-00	11.50	1.21	1.00	pump
5 Water Well 5B	(b)	19-Jul-00	13.30	1.27	1.07	pump
5 Water Well 5B	(a)	25-Oct-00	11.20	1.40	1.46	pump
5 Water Well 5C	(a)	26-Jan-00	7.71	1.28	0.96	pump
5 Water Well 5C	(a)	26-Jan-00	6.74	1.28	0.93	pump
5 Water Well 5C	(a)	19-Apr-00	7.04	1.26	0.93	pump
5 Water Well 5C	(a)	19-Jul-00	7.39	1.26	0.94	pump
5 Water Well 5C	(a)	25-Oct-00	8.10	1.38	1.34	pump
6 Water Well #4	(a)	23-Mar-00	7.80	1.25	0.94	pump
6 Water Well #4	(a)	23-Mar-00	7.32	1.24	0.92	pump
6 Water Well #4	(a)	19-Apr-00	6.28	1.28	0.92	pump
6 Water Well #4	(a)	19-Jul-00	4.92	1.24	0.87	pump
6 Water Well #4	(a)	25-Oct-00	6.30	0.50	0.51	pump
6 Water Well #4A	(a)	26-Jan-00	6.67	1.27	0.93	pump
6 Water Well #4A	(a)	26-Jan-00	6.62	1.27	0.93	pump
6 Water Well #4A	(a)	19-Apr-00	6.80	1.28	0.93	pump
6 Water Well #4A	(a)	19-Jul-00	5.51	1.24	0.88	pump
6 Water Well #4A	(a)	25-Oct-00	6.88	1.10	1.10	pump
6 Water Well C-1	(a)	26-Jan-00	15.20	2.55	1.90	pump
6 Water Well C-1	(a)	26-Jan-00	16.30	2.51	1.91	pump
6 Water Well C-1	(a)	19-Jul-00	15.20	1.23	1.09	pump
6 Water Well C-1	(a)	25-Oct-00	11.30	2.20	2.29	pump
16 UE-16d Eleana Water Well	(a)	26-Jan-00	7.05	1.28	0.95	pump
16 UE-16d Eleana Water Well	(a)	19-Apr-00	6.83	1.27	0.93	pump
16 UE-16d Eleana Water Well	(a)	19-Jul-00	6.90	1.27	0.93	pump
16 UE-16d Eleana Water Well	(a)	25-Oct-00	7.29	1.68	1.55	pump
18 Water Well 8	(a)	26-Jan-00	3.26	1.26	0.84	pump
18 Water Well 8	(a)	26-Jan-00	3.13	1.26	0.83	pump
18 Water Well 8	(a)	19-Apr-00	3.13	1.24	0.82	pump
18 Water Well 8	(a)	19-Jul-00	1.07	1.23	0.76	pump
18 Water Well 8	(a)	25-Oct-00	2.64	0.53	0.46	pump
18 Water Well 8	(b)	25-Oct-00	3.37	0.57	0.48	pump
22 Army #1 Water Well	(a)	26-Jan-00	4.94	1.28	0.89	pump
22 Army #1 Water Well	(a)	26-Jan-00	5.31	1.25	0.88	pump
22 Army #1 Water Well	(a)	19-Apr-00	4.22	1.26	0.86	pump
22 Army #1 Water Well	(a)	19-Jul-00	5.89	1.21	0.87	pump
22 Army #1 Water Well	(a)	24-Oct-00	5.40	1.11	0.86	pump
25 J-12 Water Well	(a)	26-Jan-00	4.67	1.27	0.87	pump
25 J-12 Water Well	(a)	19-Apr-00	3.85	1.24	0.84	pump
25 J-12 Water Well	(b)	19-Apr-00	4.62	1.26	0.87	pump
25 J-12 Water Well	(a)	25-Jul-00	4.78	1.18	0.83	pump
25 J-12 Water Well	(a)	24-Oct-00	4.14	0.49	0.43	pump
25 J-13 Water Well	(a)	26-Jan-00	3.97	1.27	0.86	pump
25 J-13 Water Well	(a)	25-Jul-00	3.88	1.20	0.82	pump
25 J-13 Water Well	(a)	24-Oct-00	3.65	0.41	0.36	pump
Onsite Monitoring Wells						
3 U-3cn #5	(a)	19-Jul-00	10.10	1.24	0.99	pump
5 RNM #1	(a)	28-Jun-00	24.60	1.22	1.25	pump
7 UE7nS	(a)	07-Jun-00	3.45	1.39	0.92	bailer
17 USGS HTH #1	(a)	12-Jul-00	9.12	1.26	0.99	bailer
23 SM-23-1	(a)	13-Mar-00	7.22	1.28	0.95	pump

(a) Normal sample.
(b) Field duplicate.

Table 8.4 (Summary of Gross Beta Results - 2000, cont.)

Area	Location	Sample Type	Date Sampled	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Offsite Wells and Springs							
95	Amargosa Valley RV Park	(a)	14-Nov-00	1.78	1.04	0.67	pump
95	Ash-B Piezom #1	(a)	09-Nov-00	5.48	1.03	0.84	bailer
95	Ash-B Piezom #2	(a)	14-Nov-00	7.64	0.984	0.94	bailer
95	Barn Well #2-Ponderosa Dairy	(a)	06-Dec-00	11.10	0.73	1.14	pump
95	Beatty Water and Sewer	(a)	04-Dec-00	15.70	2.55	3.52	pump
95	Big Springs	(a)	16-Jun-00	9.15	1.55	1.15	grab
95	Big Springs	(a)	06-Nov-00	7.74	1.13	0.99	grab
95	Cind-R-Lite Mine	(a)	15-Nov-00	3.33	0.523	0.42	pump
95	Cook's Ranch Well #2	(a)	05-Dec-00	9.18	2.58	2.50	pump
95	Crystal Pool	(a)	16-Jun-00	10.60	1.63	1.23	grab
95	Crystal Pool	(a)	06-Nov-00	10.60	0.985	1.11	grab
95	Crystal Trailer Park	(a)	06-Dec-00	7.09	1.80	1.56	pump
95	De Lee Ranch	(a)	05-Dec-00	6.99	0.75	2.76	pump
95	ER-OV-01	(a)	06-Nov-00	9.40	1.13	1.32	bailer
95	ER-OV-02	(a)	07-Nov-00	17.00	1.05	4.58	bailer
95	ER-OV-03A	(a)	07-Nov-00	13.80	2.17	2.62	bailer
95	ER-OV-03A3	(a)	07-Nov-00	8.27	1.08	2.33	bailer
95	ER-OV-03C	(a)	08-Nov-00	2.94	0.975	0.68	bailer
95	ER-OV-03C2	(a)	08-Nov-00	3.78	1.01	0.74	bailer
95	ER-OV-04A	(a)	08-Nov-00	7.93	0.980	0.94	bailer
95	ER-OV-05	(a)	08-Nov-00	11.40	1.08	1.18	bailer
95	ER-OV-06A	(a)	06-Nov-00	10.60	2.43	2.42	bailer
95	Fairbanks Spring	(a)	16-Jun-00	8.61	1.61	1.18	grab
95	Fairbanks Spring	(a)	06-Nov-00	8.41	1.34	1.47	grab
95	Fire Hall #2 Well	(a)	05-Dec-00	13.80	1.48	4.39	pump
95	Last Trail Ranch	(a)	05-Dec-00	13.40	4.81	1.83	pump
95	Longstreet Casino Well #1	(a)	15-Nov-00	7.98	1.10	1.23	pump
95	Longstreet Spring	(a)	16-Jun-00	8.02	1.55	1.13	grab
95	Longstreet Spring	(a)	06-Nov-00	7.94	1.16	1.38	grab
95	Nye County Well	(b)	02-Mar-00	6.16	1.14	0.84	pump
95	Nye County Well	(a)	02-Mar-00	6.51	1.14	0.84	pump
95	Peacock Ranch	(a)	07-Nov-00	10.10	2.37	2.19	grab
95	PM-3	(a)	10-Nov-00	13.50	1.13	1.81	bailer
95	PM-3	(a)	10-Nov-00	1.41	0.962	0.61	bailer
95	Revert Spring	(a)	07-Nov-00	5.59	0.990	0.82	grab
95	Road D Well	(a)	09-Nov-00	9.47	1.04	1.05	bailer
95	Roger Bright Ranch	(a)	05-Dec-00	14.30	3.91	1.94	pump
95	School Well	(a)	04-Dec-00	8.34	0.80	1.01	pump
95	Sod Farm	(a)	06-Dec-00	6.94	0.77	0.94	pump
95	Spicer Ranch	(a)	07-Nov-00	5.63	1.06	0.854	grab
95	Tolicha Peak	(a)	21-Nov-00	9.93	4.32	3.82	pump
95	TW-5	(a)	08-May-00	20.00	2.45	1.95	bailer
95	U.S. Ecology	(a)	15-Nov-00	7.92	2.12	1.76	pump
95	USW H-1	(a)	22-Jun-00	2.95	1.27	0.84	bailer
95	USW H-1	(a)	22-Jun-00	16.50	5.37	3.63	bailer
95	USW H-1	(a)	21-Jun-00	0.38	2.93	1.75	bailer

(a) Normal sample.
(b) Field duplicate.

Table 8.5 Summary of Gamma Results - 2000

Area Location	Sample Type	Date Sampled	Result (pCi/L)	Analyte	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Offsite Wells and Springs							
95 Big Springs	(a)	06-Nov-00	6.76	Lead-212	5.76	6.35	grab
95 Big Springs	(a)	06-Nov-00	6.76	Lead-212	5.76	6.35	grab
95 ER-OV-03A3	(a)	07-Nov-00	10.1	Lead-212	6.53	8.27	bailer
95 ER-OV-03A3	(a)	07-Nov-00	63.2	Potassium-40	56.3	43.4	bailer
95 ER-OV-03A3	(a)	07-Nov-00	10.1	Lead-212	6.53	8.27	bailer
95 ER-OV-06A	(a)	06-Nov-00	32.9	Potassium-40	30.6	39.6	bailer
95 Last Trail Ranch	(a)	05-Dec-00	47.7	Potassium-40	30	43.9	pump
95 Longstreet Casino Well #1	(a)	15-Nov-00	7.73	Lead-212	5.75	6.32	pump
95 Longstreet Casino Well #1	(a)	15-Nov-00	7.73	Lead-212	5.75	6.32	pump
95 Nye County Well	(b)	02-Mar-00	39.4	Bismuth-214	6.64	8.16	pump
95 Nye County Well	(a)	02-Mar-00	22.7	Bismuth-214	6.66	6.13	pump
95 Nye County Well	(b)	02-Mar-00	34.5	Lead-214	11.6	8.69	pump
95 Nye County Well	(a)	02-Mar-00	27.5	Lead-214	9.96	7.81	pump
95 Peacock Ranch	(a)	07-Nov-00	60.2	Potassium-40	18.8	35.4	grab
95 PM-3	(a)	10-Nov-00	47.4	Potassium-40	34.1	30.4	bailer
95 School Well	(a)	04-Dec-00	52.1	Potassium-40	32.6	29.1	pump
95 Spicer Ranch	(a)	07-Nov-00	195	Thorium-234	147	153	grab
95 Spicer Ranch	(a)	07-Nov-00	195	Uranium-238	147	153	grab

(a) Normal sample.

(b) Field duplicate.

Table 8.6 Summary of ^{226}Ra Results - 2000

Area	Location	Sample Type	Date Sampled	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Supply Wells							
5	Water Well 5B	(a)	25-Oct-00	0.37	0.34	0.27	pump
5	Water Well 5B	(a)	19-Jul-00	-0.01	0.15	0.06	pump
5	Water Well 5B	(b)	19-Jul-00	0.01	0.11	0.04	pump
5	Water Well 5C	(a)	26-Jan-00	0.18	0.12	0.11	pump
5	Water Well 5C	(a)	25-Oct-00	0.16	0.57	0.32	pump
5	Water Well 5C	(a)	19-Jul-00	-0.02	0.19	0.08	pump
5	Water Well 5C	(a)	19-Apr-00	0.04	0.14	0.08	pump
6	Water Well #4	(a)	25-Oct-00	0.06	0.42	0.22	pump
6	Water Well #4	(a)	23-Mar-00	0.12	0.17	0.12	pump
6	Water Well #4	(a)	19-Jul-00	0.02	0.15	0.07	pump
6	Water Well #4	(a)	19-Apr-00	0.05	0.20	0.11	pump
6	Water Well #4A	(a)	26-Jan-00	0.31	0.11	0.14	pump
6	Water Well #4A	(a)	25-Oct-00	0.11	0.29	0.17	pump
6	Water Well #4A	(a)	19-Jul-00	0.05	0.20	0.11	pump
6	Water Well #4A	(a)	19-Apr-00	0.13	0.16	0.11	pump
6	Water Well C-1	(a)	26-Jan-00	1.00	0.19	0.25	pump
6	Water Well C-1	(a)	25-Oct-00	1.31	0.60	0.55	pump
6	Water Well C-1	(a)	19-Jul-00	1.30	0.19	0.30	pump
16	UE-16d Eleana Water Well	(a)	26-Jan-00	1.45	0.18	0.29	pump
16	UE-16d Eleana Water Well	(a)	25-Oct-00	0.04	0.56	0.28	pump
16	UE-16d Eleana Water Well	(a)	19-Jul-00	1.53	0.16	0.31	pump
16	UE-16d Eleana Water Well	(a)	19-Apr-00	0.76	0.15	0.23	pump
18	Water Well 8	(a)	26-Jan-00	0.12	0.14	0.10	pump
18	Water Well 8	(a)	25-Oct-00	1.07	0.41	0.46	pump
18	Water Well 8	(b)	25-Oct-00	0.22	0.44	0.27	pump
18	Water Well 8	(a)	19-Jul-00	0.02	0.18	0.08	pump
18	Water Well 8	(a)	19-Apr-00	0.05	0.10	0.06	pump
22	Army #1 Water Well	(a)	26-Jan-00	0.64	0.15	0.21	pump
22	Army #1 Water Well	(a)	24-Oct-00	5.97	1.09	1.81	pump
22	Army #1 Water Well	(a)	19-Jul-00	0.47	0.12	0.18	pump
22	Army #1 Water Well	(a)	19-Apr-00	0.24	0.21	0.16	pump
25	J-12 Water Well	(a)	26-Jan-00	0.01	0.14	0.06	pump
25	J-12 Water Well	(a)	25-Jul-00	0.03	0.14	0.07	pump
25	J-12 Water Well	(a)	24-Oct-00	0.21	0.50	0.30	pump
25	J-12 Water Well	(a)	19-Apr-00	0.07	0.11	0.07	pump
25	J-12 Water Well	(b)	19-Apr-00	0.23	0.10	0.12	pump
25	J-13 Water Well	(a)	26-Jan-00	-0.06	0.19	0.07	pump
25	J-13 Water Well	(a)	25-Jul-00	0.01	0.16	0.07	pump

(a) Normal sample.
(b) Field duplicate.

Table 8.6 (Summary of ^{226}Ra Results - 2000, cont.)

Area	Location	Sample Type	Date Sampled	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Monitoring Wells							
3	U-3cn #5	(a)	19-Jul-00	1.61	.158	.298	pump
5	RNM #1	(a)	28-Jun-00	-0.147	.163	.0657	pump
7	UE7nS	(a)	07-Jun-00	0.21	0.14	0.12	bailer
17	USGS HTH #1	(a)	12-Jul-00	0.31	0.14	0.16	bailer
23	SM-23-1	(a)	13-Mar-00	0.30	0.20	0.17	pump
Offsite Wells and Springs							
95	Amargosa Valley RV Park	(a)	14-Nov-00	0.59	0.43	0.40	pump
95	Barn Well #2-Ponderosa Dairy	(a)	06-Dec-00	0.79	0.50	0.44	pump
95	Beatty Water and Sewer	(a)	04-Dec-00	0.17	0.45	0.26	pump
95	Big Springs	(a)	16-Jun-00	0.15	0.15	0.11	grab
95	Big Springs	(a)	06-Nov-00	0.68	0.51	0.39	grab
95	Cind-R-Lite Mine	(a)	15-Nov-00	0.41	0.59	0.39	pump
95	Cook's Ranch Well #2	(a)	05-Dec-00	0.80	0.14	0.39	pump
95	Crystal Pool	(a)	16-Jun-00	0.46	0.15	0.17	grab
95	Crystal Pool	(a)	06-Nov-00	0.16	0.08	0.14	grab
95	Crystal Trailer Park	(a)	06-Dec-00	-0.10	0.58	0.23	pump
95	De Lee Ranch	(a)	05-Dec-00	1.18	0.67	0.56	pump
95	Fairbanks Spring	(a)	16-Jun-00	0.34	0.15	0.16	grab
95	Fairbanks Spring	(a)	06-Nov-00	0.19	0.54	0.31	grab
95	Fire Hall #2 Well	(a)	05-Dec-00	1.79	0.76	0.73	pump
95	Last Trail Ranch	(a)	05-Dec-00	0.64	0.64	0.45	pump
95	Longstreet Casino Well #1	(a)	15-Nov-00	0.65	1.01	0.65	pump
95	Longstreet Spring	(a)	16-Jun-00	0.30	0.13	0.15	grab
95	Longstreet Spring	(a)	06-Nov-00	0.06	0.28	0.15	grab
95	Peacock Ranch	(a)	07-Nov-00	-0.19	0.45	0.15	grab
95	Revert Spring	(a)	07-Nov-00	-0.09	0.44	0.18	grab
95	Road D Well	(a)	09-Nov-00	0.79	0.62	0.47	bailer
95	Roger Bright Ranch	(a)	05-Dec-00	1.08	0.47	0.48	pump
95	School Well	(a)	04-Dec-00	0.35	0.69	0.42	pump
95	Sod Farm	(a)	06-Dec-00	0.05	0.66	0.33	pump
95	Spicer Ranch	(a)	07-Nov-00	0.4	0.524	0.351	grab
95	Tolicha Peak	(a)	21-Nov-00	0.49	0.84	0.53	pump
95	TW-5	(a)	08-May-00	0.73	0.33	0.38	bailer
95	U.S. Ecology	(a)	15-Nov-00	-0.05	0.64	0.30	pump
95	USW H-1	(a)	22-Jun-00	0.91	0.17	0.25	bailer
95	USW H-1	(a)	22-Jun-00	0.04	0.17	0.09	bailer
95	USW H-1	(a)	21-Jun-00	0.03	0.16	0.08	bailer

(a) Normal sample.

(b) Field duplicate.

Table 8.7 Summary of ^{228}Ra Results - 2000

Area	Location	Sample Type	Date Sampled	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Supply Wells							
5	Water Well 5B	(a)	25-Oct-00	0.91	1.95	1.17	pump
5	Water Well 5B	(a)	19-Jul-00	0.12	0.16	0.16	pump
5	Water Well 5B	(b)	19-Jul-00	-0.18	0.98	0.46	pump
5	Water Well 5C	(a)	25-Oct-00	1.12	1.61	0.99	pump
5	Water Well 5C	(a)	19-Jul-00	0.06	1.03	0.54	pump
5	Water Well 5C	(a)	19-Apr-00	0.11	0.64	0.34	pump
5	Water Well 5C	(a)	26-Jan-00	0.31	1.12	0.65	pump
6	Water Well #4	(a)	25-Oct-00	1.26	1.72	1.06	pump
6	Water Well #4	(a)	19-Jul-00	0.51	0.77	0.51	pump
6	Water Well #4	(a)	19-Apr-00	0.06	1.21	0.65	pump
6	Water Well #4	(a)	23-Mar-00	0.51	2.18	1.28	pump
6	Water Well #4A	(a)	25-Oct-00	0.82	1.87	1.12	pump
6	Water Well #4A	(a)	19-Jul-00	0.25	0.75	0.43	pump
6	Water Well #4A	(a)	19-Apr-00	0.27	0.65	0.39	pump
6	Water Well #4A	(a)	26-Jan-00	0.39	0.93	0.56	pump
6	Water Well C-1	(a)	25-Oct-00	0.81	1.68	1.01	pump
6	Water Well C-1	(a)	19-Jul-00	0.54	0.72	0.49	pump
6	Water Well C-1	(a)	26-Jan-00	0.93	0.91	0.65	pump
16	UE-16d Eleana Water Well	(a)	25-Oct-00	0.76	1.66	1.00	pump
16	UE-16d Eleana Water Well	(a)	19-Jul-00	0.45	0.67	0.45	pump
16	UE-16d Eleana Water Well	(a)	19-Apr-00	0.20	1.09	0.60	pump
16	UE-16d Eleana Water Well	(a)	26-Jan-00	-0.05	0.91	0.45	pump
18	Water Well 8	(a)	25-Oct-00	0.01	1.69	0.96	pump
18	Water Well 8	(b)	25-Oct-00	-0.01	1.38	0.78	pump
18	Water Well 8	(a)	19-Jul-00	0.07	1.27	0.67	pump
18	Water Well 8	(a)	19-Apr-00	0.20	0.13	0.20	pump
18	Water Well 8	(a)	26-Jan-00	0.06	0.82	0.41	pump
22	Army #1 Water Well	(a)	24-Oct-00	2.00	1.77	1.15	pump
22	Army #1 Water Well	(a)	19-Jul-00	0.56	1.04	0.64	pump
22	Army #1 Water Well	(a)	19-Apr-00	0.18	0.71	0.39	pump
22	Army #1 Water Well	(a)	26-Jan-00	0.30	1.08	0.62	pump
25	J-12 Water Well	(a)	24-Oct-00	1.26	1.58	0.99	pump
25	J-12 Water Well	(a)	25-Jul-00	0.26	0.69	0.41	pump
25	J-12 Water Well	(a)	19-Apr-00	0.35	0.75	0.46	pump
25	J-12 Water Well	(b)	19-Apr-00	0.24	0.58	0.35	pump
25	J-12 Water Well	(a)	26-Jan-00	0.22	0.78	0.44	pump
25	J-13 Water Well	(a)	24-Oct-00	0.30	1.51	0.88	pump
25	J-13 Water Well	(a)	25-Jul-00	0.29	0.16	0.26	pump
25	J-13 Water Well	(a)	26-Jan-00	0.28	0.15	0.25	pump

(a) Normal sample.
(b) Field duplicate.

Table 8.7 (Summary of ^{228}Ra Results - 2000, cont.)

Area	Location	Sample Type	Date Sampled	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Monitoring Wells							
3	U-3cn #5	(a)	19-Jul-00	1.27	0.66	0.62	pump
5	RNM #1	(a)	28-Jun-00	0.06	0.78	0.39	pump
7	UE7nS	(a)	07-Jun-00	0.05	0.62	0.31	bailer
17	USGS HTH #1	(a)	12-Jul-00	0.22	0.20	0.25	bailer
23	SM-23-1	(a)	13-Mar-00	-0.06	2.24	1.27	pump
Offsite Wells and Springs							
95	Amargosa Valley RV Park	(a)	14-Nov-00	0.43	1.34	0.79	pump
95	Barn Well #2-Ponderosa Dairy		06-Dec-00	0.07	1.35	0.78	pump

Table 8.8 Summary of ^{238}Pu Results - 2000

Area	Location	Sample Type	Date Sampled	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Supply Wells							
5	Water Well 5B	(a)	19-Jul-00	-0.0011	0.013	0.0029	pump
5	Water Well 5B	(b)	19-Jul-00	-0.0015	0.017	0.0040	pump
5	Water Well 5C	(a)	19-Jul-00	-0.0011	0.014	0.0031	pump
6	Water Well #4	(a)	19-Jul-00	0.0011	0.017	0.0064	pump
6	Water Well #4A	(a)	19-Jul-00	-0.0011	0.014	0.0031	pump
6	Water Well C-1	(a)	19-Jul-00	-0.0011	0.013	0.0031	pump
16	UE-16d Eleana Water Well	(a)	19-Jul-00	-0.0012	0.015	0.0033	pump
18	Water Well 8	(a)	19-Jul-00	0.0011	0.015	0.0057	pump
22	Army #1 Water Well	(a)	19-Jul-00	0.0010	0.014	0.0054	pump
25	J-12 Water Well	(a)	25-Jul-00	-0.0011	0.014	0.0031	pump
25	J-13 Water Well	(a)	25-Jul-00	-0.0012	0.015	0.0034	pump
Onsite Monitoring Wells							
3	U-3cn #5	(a)	19-Jul-00	-0.0011	0.014	0.0031	pump
5	RNM #1	(a)	28-Jun-00	-0.0011	0.014	0.0031	pump
7	UE7nS	(a)	07-Jun-00	-0.0021	0.025	0.0058	bailer
17	USGS HTH #1	(a)	12-Jul-00	-0.0011	0.013	0.0029	bailer
Offsite Wells and Springs							
95	Amargosa Valley RV Park	(a)	14-Nov-00	-0.0071	0.039	0.0098	pump
95	Ash-B Piezom #1	(a)	09-Nov-00	0.0084	0.036	0.0166	bailer
95	Ash-B Piezom #2	(a)	14-Nov-00	0.0000	0.012	0.0000	bailer
95	Barn Well #2-Ponderosa Dairy	(a)	06-Dec-00	0.0047	0.014	0.0093	pump
95	Beatty Water and Sewer	(a)	04-Dec-00	0.0038	0.059	0.0292	pump
95	Big Springs	(a)	16-Jun-00	0.0011	0.016	0.0062	grab
95	Big Springs	(a)	06-Nov-00	0.0035	0.034	0.0155	grab
95	Cind-R-Lite Mine	(a)	15-Nov-00	0.0069	0.021	0.0136	pump
95	Cook's Ranch Well #2	(a)	05-Dec-00	0.0000	0.028	0.0102	pump
95	Crystal Pool	(a)	16-Jun-00	0.0035	0.016	0.0079	grab
95	Crystal Pool	(a)	06-Nov-00	0.0059	0.018	0.0116	grab
95	Crystal Trailer Park	(a)	06-Dec-00	0.0467	0.0286	0.029	pump
95	De Lee Ranch	(a)	05-Dec-00	-0.0046	0.036	0.0091	pump
95	ER-OV-01	(a)	06-Nov-00	-0.0007	0.044	0.0166	bailer
95	ER-OV-02	(a)	07-Nov-00	0.0626	0.043	0.0383	bailer

(a) Normal sample.
(b) Field duplicate.

Table 8.8 (Summary of ^{238}Pu Results - 2000, cont.)

Area Location		Sample Type	Date Sampled	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Offsite Wells and Springs, cont.							
95	ER-OV-03A	(a)	07-Nov-00	-0.0049	0.060	0.0219	bailer
95	ER-OV-03A3	(a)	07-Nov-00	0.0014	0.035	0.0120	bailer
95	ER-OV-03C	(a)	08-Nov-00	0.0067	0.020	0.0130	bailer
95	ER-OV-03C2	(a)	08-Nov-00	0.0125	0.013	0.0141	bailer
95	ER-OV-04A	(a)	08-Nov-00	-0.0033	0.058	0.0281	bailer
95	ER-OV-05	(a)	08-Nov-00	0.0118	0.012	0.0133	bailer
95	ER-OV-06A	(a)	06-Nov-00	0.0050	0.015	0.0097	bailer
95	Fairbanks Spring	(a)	16-Jun-00	0.0009	0.013	0.0051	grab
95	Fairbanks Spring	(a)	06-Nov-00	0.0014	0.034	0.0117	grab
95	Fire Hall #2 Well	(a)	05-Dec-00	-0.0072	0.035	0.0100	pump
95	Last Trail Ranch	(a)	05-Dec-00	-0.0042	0.040	0.0142	pump
95	Longstreet Casino Well #1	(a)	15-Nov-00	-0.0064	0.035	0.0089	pump
95	Longstreet Spring	(a)	16-Jun-00	-0.0014	0.016	0.0037	grab
95	Longstreet Spring	(a)	06-Nov-00	-0.0070	0.041	0.0096	grab
95	Nye County Well	(b)	02-Mar-00	-0.0014	0.017	0.0038	pump
95	Nye County Well	(a)	02-Mar-00	-0.0012	0.014	0.0032	pump
95	Peacock Ranch	(a)	07-Nov-00	0.0000	0.022	0.0000	grab
95	PM-3	(a)	10-Nov-00	0.0037	0.029	0.0127	bailer
95	PM-3	(a)	10-Nov-00	0.0235	0.018	0.0231	bailer
95	Revert Spring	(a)	07-Nov-00	0.0000	0.015	0.0000	grab
95	Road D Well	(a)	09-Nov-00	0.0111	0.011	0.0126	bailer
95	Roger Bright Ranch	(a)	05-Dec-00	0.0040	0.012	0.0078	pump
95	School Well	(a)	04-Dec-00	0.0036	0.035	0.0159	pump
95	Sod Farm	(a)	06-Dec-00	-0.0119	0.044	0.0135	pump
95	Spicer Ranch	(a)	07-Nov-00	0.0162	0.0244	0.0225	grab
95	Tolicha Peak	(a)	21-Nov-00	0.0408	0.042	0.0315	pump
95	TW-5	(a)	08-May-00	-0.0013	0.016	0.0035	bailer
95	U.S. Ecology	(a)	15-Nov-00	0.0000	0.017	0.0000	pump
95	USW H-1	(a)	22-Jun-00	-0.0011	0.013	0.0030	bailer
95	USW H-1	(a)	22-Jun-00	-0.0020	0.024	0.0056	bailer
95	USW H-1	(a)	21-Jun-00	-0.0011	0.014	0.0031	bailer

(a) Normal sample.
(b) Field duplicate.

Table 8.9 Summary of $^{239+240}Pu$ Results - 2000

Area Location		Sample Type	Date Sampled	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Supply Wells							
5	Water Well 5B	(a)	19-Jul-00	0.0026	0.0141	0.0067	pump
5	Water Well 5B	(b)	19-Jul-00	0.0008	0.0183	0.0069	pump
5	Water Well 5C	(a)	19-Jul-00	0.0027	0.0150	0.0071	pump
6	Water Well #4	(a)	19-Jul-00	-0.0018	0.0175	0.0043	pump
6	Water Well #4A	(a)	19-Jul-00	0.0049	0.0149	0.0083	pump
6	Water Well C-1	(a)	19-Jul-00	0.0173	0.0146	0.0131	pump
16	UE-16d Eleana Water Well	(a)	19-Jul-00	0.0075	0.0159	0.0099	pump
18	Water Well 8	(a)	19-Jul-00	-0.0017	0.0162	0.0040	pump
22	Army #1 Water Well	(a)	19-Jul-00	-0.0016	0.0153	0.0037	pump
25	J-12 Water Well	(a)	25-Jul-00	0.0049	0.0150	0.0083	pump
25	J-13 Water Well	(a)	25-Jul-00	0.0098	0.0160	0.0110	pump
Onsite Monitoring Wells							
3	U-3cn #5	(a)	19-Jul-00	-0.0016	0.0149	0.0037	pump
5	RNM #1	(a)	28-Jun-00	0.0091	0.0148	0.0102	pump
7	UE7nS	(a)	07-Jun-00	0.0010	0.0275	0.0103	bailer
17	USGS HTH #1	(a)	12-Jul-00	0.0065	0.0139	0.0087	bailer
Offsite Wells And Springs							
95	Amargosa Valley RV Park	(a)	14-Nov-00	0.0130	0.0130	0.0148	pump
95	Ash-B Piezom #1	(a)	09-Nov-00	0.0169	0.0169	0.0192	bailer
95	Ash-B Piezom #2	(a)	14-Nov-00	0.0000	0.0114	0.0000	bailer
95	Barn Well #2-Ponderosa Dairy	(a)	06-Dec-00	-0.0095	0.0582	0.0227	pump
95	Beatty Water and Sewer	(a)	04-Dec-00	0.0077	0.0115	0.0107	pump
95	Big Springs	(a)	16-Jun-00	0.0031	0.0173	0.0082	grab
95	Big Springs	(a)	06-Nov-00	0.0141	0.0106	0.0139	grab
95	Cind-R-Lite Mine	(a)	15-Nov-00	0.0069	0.0207	0.0136	pump
95	Cook's Ranch Well #2	(a)	05-Dec-00	-0.0037	0.0281	0.0072	pump
95	Crystal Pool	(a)	16-Jun-00	-0.0018	0.0172	0.0043	grab
95	Crystal Pool	(a)	06-Nov-00	0.0059	0.0177	0.0116	grab
95	Crystal Trailer Park	(a)	06-Dec-00	0.0074	0.0284	0.0146	pump
95	De Lee Ranch	(a)	05-Dec-00	0.0000	0.0139	0.0000	pump
95	ER-OV-01	(a)	06-Nov-00	0.0160	0.0386	0.0218	bailer
95	ER-OV-02	(a)	07-Nov-00	0.0028	0.0427	0.0170	bailer

(a) Normal sample.
(b) Field duplicate.

Table 8.9 (Summary of $^{239+240}Pu$ Results - 2000, cont.)

Area Location	Sample Type	Date Sampled	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Offsite Wells And Springs, cont.						
95 ER-OV-03A	(a)	07-Nov-00	-0.0104	0.0604	0.0191	bailer
95 ER-OV-03A3	(a)	07-Nov-00	0.0064	0.0345	0.0155	bailer
95 ER-OV-03C	(a)	08-Nov-00	-0.0096	0.0570	0.0133	bailer
95 ER-OV-03C2	(a)	08-Nov-00	0.0008	0.0299	0.0105	bailer
95 ER-OV-04A	(a)	08-Nov-00	0.0033	0.0251	0.0111	bailer
95 ER-OV-05	(a)	08-Nov-00	0.0000	0.0118	0.0000	bailer
95 ER-OV-06A	(a)	06-Nov-00	0.0099	0.0149	0.0138	bailer
95 Fairbanks Spring	(a)	16-Jun-00	-0.0015	0.0144	0.0036	grab
95 Fairbanks Spring	(a)	06-Nov-00	0.0048	0.0145	0.0095	grab
95 Fire Hall #2 Well	(a)	05-Dec-00	-0.0072	0.0346	0.0100	pump
95 Last Trail Ranch	(a)	05-Dec-00	0.0125	0.0125	0.0142	pump
95 Longstreet Casino Well #1	(a)	15-Nov-00	-0.0032	0.0284	0.0063	pump
95 Longstreet Spring	(a)	16-Jun-00	0.0006	0.0170	0.0064	grab
95 Longstreet Spring	(a)	06-Nov-00	-0.0070	0.0414	0.0096	grab
95 Nye County Well	(b)	02-Mar-00	-0.0021	0.0183	0.0046	pump
95 Nye County Well	(a)	02-Mar-00	0.0004	0.0153	0.0057	pump
95 Peacock Ranch	(a)	07-Nov-00	0.0075	0.0224	0.0146	grab
95 PM-3	(a)	10-Nov-00	-0.0037	0.0285	0.0073	bailer
95 PM-3	(a)	10-Nov-00	0.0000	0.0176	0.0000	bailer
95 Revert Spring	(a)	07-Nov-00	0.0151	0.0151	0.0172	grab
95 Road D Well	(a)	09-Nov-00	0.0000	0.0111	0.0000	bailer
95 Roger Bright Ranch	(a)	05-Dec-00	-0.0079	0.0379	0.0110	pump
95 School Well	(a)	04-Dec-00	0.0109	0.0109	0.0123	pump
95 Sod Farm	(a)	06-Dec-00	0.0119	0.0119	0.0135	pump
95 Spicer Ranch	(a)	07-Nov-00	0.00812	0.0243	0.0159	grab
95 Tolicha Peak	(a)	21-Nov-00	0.0000	0.0398	0.0173	pump
95 TW-5	(a)	08-May-00	-0.0019	0.0174	0.0043	bailer
95 U.S. Ecology	(a)	15-Nov-00	0.0057	0.0171	0.0112	pump
95 USW H-1	(a)	22-Jun-00	0.0006	0.0142	0.0054	bailer
95 USW H-1	(a)	22-Jun-00	0.0087	0.0265	0.0147	bailer
95 USW H-1	(a)	21-Jun-00	0.0006	0.0148	0.0056	bailer

(a) Normal sample.
(b) Field duplicate.

Table 8.10 Summary of ^{90}Sr Results - 2000

Area	Location	Sample Type	Date Sampled	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Supply Wells							
5	Water Well 5B	(a)	19-Jul-00	0.057	0.278	0.160	pump
5	Water Well 5B	(b)	19-Jul-00	0.053	0.394	0.225	pump
5	Water Well 5C	(a)	19-Jul-00	0.103	0.362	0.213	pump
5	Water Well 5C	(a)	19-Apr-00	0.028	0.253	0.144	pump
6	Water Well #4	(a)	19-Jul-00	0.291	0.585	0.355	pump
6	Water Well #4	(a)	19-Apr-00	-0.032	0.232	0.126	pump
6	Water Well #4A	(a)	19-Jul-00	-0.025	0.309	0.170	pump
6	Water Well #4A	(a)	19-Apr-00	-0.007	0.246	0.136	pump
6	Water Well C-1	(a)	19-Jul-00	0.027	0.482	0.271	pump
16	UE-16d Eleana Water Well	(a)	19-Jul-00	0.012	0.462	0.260	pump
16	UE-16d Eleana Water Well	(a)	19-Apr-00	-0.032	0.201	0.110	pump
18	Water Well 8	(a)	19-Jul-00	-0.173	0.490	0.256	pump
18	Water Well 8	(a)	19-Apr-00	0.024	0.276	0.156	pump
22	Army #1 Water Well	(a)	19-Jul-00	-0.122	0.394	0.210	pump
22	Army #1 Water Well	(a)	19-Apr-00	0.090	0.237	0.140	pump
25	J-12 Water Well	(a)	25-Jul-00	0.140	0.339	0.202	pump
25	J-12 Water Well	(a)	19-Apr-00	0.183	0.503	0.298	pump
25	J-12 Water Well	(b)	19-Apr-00	0.072	0.190	0.113	pump
25	J-13 Water Well	(a)	25-Jul-00	0.049	0.321	0.185	pump
Onsite Monitoring Wells							
3	U-3cn #5	(a)	19-Jul-00	-0.065	0.591	0.323	pump
5	RNM #1	(a)	28-Jun-00	5.800	0.291	0.448	pump
5	UE-5c Water Well	(a)	19-Apr-00	0.111	0.328	0.194	pump
7	UE7nS	(a)	07-Jun-00	-0.129	0.402	0.209	bailer
17	USGS HTH #1	(a)	12-Jul-00	0.337	1.020	0.600	bailer
Offsite Wells and Springs							
95	Amargosa Valley RV Park	(a)	14-Nov-00	-0.053	0.515	0.296	pump
95	Ash-B Piezom #1	(a)	09-Nov-00	0.130	0.293	0.175	bailer
95	Ash-B Piezom #2	(a)	14-Nov-00	0.019	0.633	0.369	bailer
95	Barn Well #2-Ponderosa Dairy	(a)	06-Dec-00	-0.289	1.110	0.610	pump
95	Barn Well #2-Ponderosa Dairy	(a)	06-Dec-00	-0.289	1.110	0.610	pump
95	Beatty Water and Sewer	(a)	04-Dec-00	0.093	0.957	0.545	pump
95	Big Springs	(a)	16-Jun-00	0.092	0.263	0.155	grab
95	Big Springs	(a)	06-Nov-00	0.165	0.404	0.239	grab
95	Cind-R-Lite Mine	(a)	15-Nov-00	0.061	0.503	0.294	pump
95	Cook's Ranch Well #2	(a)	05-Dec-00	-0.146	0.738	0.406	pump
95	Crystal Pool	(a)	16-Jun-00	0.015	0.267	0.150	grab
95	Crystal Pool	(a)	06-Nov-00	0.185	0.459	0.272	grab

(a) Normal sample.
(b) Field duplicate.

Table 8.10 (Summary of ^{90}Sr Results - 2000, cont.)

Area	Location	Sample Type	Date Sampled	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Offsite Wells and Springs, cont.							
95	Crystal Trailer Park	(a)	06-Dec-00	0.086	0.616	0.352	pump
95	De Lee Ranch	(a)	05-Dec-00	-0.339	1.100	0.604	pump
95	ER-OV-01	(a)	06-Nov-00	0.182	0.639	0.373	bailer
95	ER-OV-02	(a)	07-Nov-00	0.156	0.822	0.477	bailer
95	ER-OV-03A	(a)	07-Nov-00	0.285	0.670	0.399	bailer
95	ER-OV-03A3	(a)	07-Nov-00	0.382	0.706	0.425	bailer
95	ER-OV-03C	(a)	08-Nov-00	0.027	0.574	0.332	bailer
95	ER-OV-03C2	(a)	08-Nov-00	-0.026	0.288	0.166	bailer
95	ER-OV-04A	(a)	08-Nov-00	-0.043	0.285	0.164	bailer
95	ER-OV-05	(a)	08-Nov-00	-0.013	0.285	0.164	bailer
95	ER-OV-06A	(a)	06-Nov-00	0.164	0.729	0.427	bailer
95	Fairbanks Spring	(a)	16-Jun-00	0.008	0.286	0.161	grab
95	Fairbanks Spring	(a)	06-Nov-00	0.225	0.627	0.373	grab
95	Fire Hall #2 Well	(a)	05-Dec-00	0.593	0.931	0.568	pump
95	Last Trail Ranch	(a)	05-Dec-00	0.557	0.988	0.596	pump
95	Longstreet Casino Well #1	(a)	15-Nov-00	0.049	0.699	0.407	pump
95	Longstreet Spring	(a)	16-Jun-00	0.028	0.265	0.151	grab
95	Longstreet Spring	(a)	06-Nov-00	0.044	0.437	0.250	grab
95	Nye County Well	(b)	02-Mar-00	0.117	0.457	0.267	pump
95	Nye County Well	(a)	02-Mar-00	0.106	0.325	0.192	pump
95	Peacock Ranch	(a)	07-Nov-00	0.034	0.721	0.407	grab
95	PM-3	(a)	10-Nov-00	0.031	0.275	0.160	bailer
95	PM-3	(a)	10-Nov-00	-0.146	0.479	0.269	bailer
95	Revert Spring	(a)	07-Nov-00	0.286	0.792	0.467	grab
95	Road D Well	(a)	09-Nov-00	-0.105	0.334	0.192	bailer
95	Roger Bright Ranch	(a)	05-Dec-00	0.139	0.822	0.474	pump
95	School Well	(a)	04-Dec-00	0.425	0.791	0.475	pump
95	Sod Farm	(a)	06-Dec-00	-0.258	1.260	0.698	pump
95	Spicer Ranch	(a)	07-Nov-00	-0.101	0.817	0.457	grab
95	Tolicha Peak	(a)	21-Nov-00	0.256	0.644	0.383	pump
95	TW-5	(a)	08-May-00	0.092	0.303	0.177	bailer
95	U.S. Ecology	(a)	15-Nov-00	0.295	0.541	0.324	pump
95	USW H-1	(a)	22-Jun-00	0.124	0.264	0.160	bailer
95	USW H-1	(a)	22-Jun-00	0.413	0.266	0.186	bailer
95	USW H-1	(a)	21-Jun-00	-0.034	0.434	0.240	bailer

(a) Normal sample.
(b) Field duplicate.

Table 8.11 Summary of the DRI Groundwater Monitoring Program - 2000

Monitoring Location	Date	Sampling Method	Analysis
Amargosa Valley RV-Park	07/25/00	pump	Enriched Tritium
Ash-B#1[(a)]	05/11/00	bail	Enriched Tritium
Beatty Water and Sewer	07/26/00	pump	Enriched Tritium
Beatty Water and Sewer - Barrick/Bullfrog[(b)]	08/24/00	pump	Enriched Tritium
Cinderlite Mine	07/25/00	pump	Enriched Tritium
Coffers Ranch Windmill	09/06/00	windmill	Enriched Tritium, Gross Alpha, Gross Beta, Gamma Spectroscopy, ^{238}Pu, $^{239+240}$Pu
Cooks Ranch Well #2	07/25/00	pump	Enriched Tritium
De Lee Ranch	08/03/00	pump	Enriched Tritium
ER-OV-01	05/09/00	bail	Enriched Tritium, Gross Alpha, Gross Beta, Gamma Spectroscopy, ^{238}Pu, $^{239+240}$Pu
ER-OV-02	05/31/00 and 05/11/00	Bennet pump and bailed	Enriched Tritium, Gross Alpha, Gross Beta, Gamma Spectroscopy, ^{238}Pu, $^{239+240}$Pu
ER-OV-03a	05/31/00	bail	Enriched Tritium
ER-OV-03a2[(c)]	05/31/00	bail	No analysis conducted, sample too muddy.
ER-OV-03c	05/09/00	bail	Enriched Tritium, Gross Alpha, Gross Beta, Gamma Spectroscopy, ^{238}Pu, $^{239+240}$Pu

(a) Diameter of Ash B#2 was too small to allow access for DRI sampling tool. An alternative sample point was not selected.

(b) Beatty Water and Sewer - Barrick/Bullfrog was utilized as a supplemental sample point for Beatty.

(c) ER-OV-3a3 casing was pinched 80 ft. below ground surface. ER-OV-03a2 was selected as its replacement.

(d) Road D Well Spicer was misnamed. Actual sample point is Tolicha Peak J-2. Spicer Springs provided a cover sample point closet to an intended sample point near Spicer Ranch.

(e) Access to the Cherry Patch Ranch Well was denied by the owner. The Short Branch Saloon Well was selected as an alternative.

Table 8.11 (Summary of the DRI Groundwater Monitoring Program - 2000, cont.)

Monitoring Location	Date	Sampling Method	Analysis
ER-OV-03c2	05/09/00	bail	Enriched Tritium, Gross Alpha, Gross Beta, Gamma Spectroscopy, ^{238}Pu, $^{239+240}$Pu
ER-OV-04a	05/31/00	bail	Enriched Tritium
ER-OV-05	05/31/00	bail	Enriched Tritium
ER-OV-06a	05/09/00	bail	Enriched Tritium, Gross Alpha, Gross Beta, Gamma Spectroscopy, ^{238}Pu, $^{239+240}$Pu
Fire Hall #2	07/25/00	pump	Enriched Tritium
Last Trail Ranch	07/26/00	pump	Enriched Tritium
Long Street Casino Well #1	07/25/00	pump	Enriched Tritium
U.S. Ecology	07/26/00	pump	Enriched Tritium
pm-3#1	09/26/00	bail	Enriched Tritium, Gross Alpha, Gross Beta, Gamma Spectroscopy
pm-3#2	10/11/00	Bennet Pump	Enriched Tritium, Gross Alpha, Gross Beta, Gamma Spectroscopy
Tolicha Peak J-2(d)	08/30/00	Bennet Pump	Enriched Tritium
Roger Bright Ranch	07/25/00	pump	Enriched Tritium
School Well	07/25/00	pump	Enriched Tritium
Short Branch Saloon(e)	08/03/00	pump	Enriched Tritium
Spicer Springs(d)	08/03/00	hand sampled	Enriched Tritium
Tolicha Peak	08/03/00	pump	Enriched Tritium
TW-5	05/08/00	bail	Enriched Tritium

(a) Diameter of Ash B#2 was too small to allow access for DRI sampling tool. An alternative sample point was not selected.

(b) Beatty Water and Sewer - Barrick/Bullfrog was utilized as a supplemental sample point for Beatty.

(c) ER-OV-3a3 casing was pinched 80 ft. below ground surface. ER-OV-03a2 was selected as its

(d) Road D Well Spicer was misnamed. Actual sample point is Tolicha Peak J-2. Spicer Springs provided

(e) Access to the Cherry Patch Ranch Well was denied by the owner. The Short Branch Saloon Well was

Table 8.12 Summary of DRI Groundwater Tritium Results - 2000

Wells Sampled	Severn Trent Enriched Tritium Results (pCi/L) ± Total Error, MDC [a]	University of Waterloo Enriched Tritium Results (pCi/L) ± Total Error, MDC	CY 2000 BN Results [b]
pm-3#1	5.27 ± 4.8, 6.48		-4.69 ± 5.6, 9.7
pm-3#2 - bailed	10.7 ± 5.1, 6.45		1.28 ± 5.9, 10
pm-3#2 - pumped	12.1 ± 5.1, 6.39		
Amargosa Valley RV-Park	7.89 ± 3.8, 4.45		1.46 ± 6.6, 11.1
Ash-B#1	34.2 ± 5.4, 4.45	<2.55 ± 1.60	16.4 ± 7.8, 14
Cooks Ranch Well #2	9.07 ± 3.8, 4.39		9.5 ± 6.8, 11.3
Beatty Water an Sewer	16.2 ± 4.2, 4.4		3.3 ± 7.8, 13.2
Beatty Water an Sewer-Barrick/Bullfrog	5.36 ± 3.6, 4.41		
Beatty Distribution System - Exchange Club		<2.55 ± 1.60	
Short Branch Saloon	21.3 ± 4.5, 4.39		
Cinderlite Mine	6.8 ± 3.7, 4.42		-1.6 ± 7.2, 12.4
Coffers Ranch Windmill	6.29 ± 4.8, 6.4		
De Lee Ranch	5.98 ± 3.7, 4.42		3.6 ± 7.7, 7.7
Fire Hall #2	7.81 ± 3.7, 4.4		-7.9 ± 6.3, 11.1
Last Trail Ranch	14.6 ± 4.1, 4.4		-7 ± 6.2, 10.7
Long Street Casino Well #1	12.5 ± 4.0, 4.42		0.2 ± 63.5, 105.05
U.S. Ecology	14.3 ± 4.1, 4.41		0.4 ± 6.3, 10.7
Tolicha Peak J-2	12.7 ± 4.0, 4.42		0.26 ± 5.9, 10.1
Spicer Springs	5.49 ± 3.6, 4.36		-15.2 ± 8.2, 14.3
Roger Bright Ranch	15.4 ± 4.2, 4.43		-4.7 ± 6.2, 10.7
School Well	15 ± 4.1, 4.3		-7 ± 6.3, 11
TW-5	33.5 ± 5.4, 4.47	<2.55 ± 1.60	-2.68 ± 6.67, 11.2
Tolicha Peak	15 ± 4.1, 4.36		5.6 ± 6.3, 10.6
ER-OV-01	20.6 ± 4.5, 4.4	<2.55 ± 1.60	-4.4 ± 6.3, 11
ER-OV-02 - bailed	19.4 ± 4.4, 4.41	<2.55 ± 1.60	-7.7 ± 6.67, 11.3
ER-OV-02 - pumped	114 ± 12.0, 4.48	<2.55 ± 1.60	
ER-OV-03a	138 ± 14.00, 4.53	<2.55 ± 1.60	-6.2 ± 6.3, 10.8
ER-OV-03a - duplicate	26.6 ± 4.91, 4.43	<2.55 ± 1.60	
ER-OV03c	19.7 ± 4.4, 4.36	<2.55 ± 1.60	-5.99 ± 5.49, 9.26
ER-OV-03c2	10 ± 3.9, 4.36		-6.71 ± 5.8, 9.79
ER-OV-04a	142 ± 14.00, 4.39	<2.55 ± 1.60	3.1 ± 6.3, 10.8
ER-OV-05	114 ± 12.00, 4.47	<2.55 ± 1.60	-9.8 ± 6.6, 11.5
ER-OV-6a	34.7 ± 5.50, 4.47	<2.55 ± 1.60	0.446 ± 6.3, 10.5

(a) Results of associated field quality assurance samples demonstrated a large degree of variability between analyses and overestimated tritium concentrations in field control samples. All analyses have a low degree of confidence and may overestimate the actual amount of tritium present.

(b) Results from collection date nearest DRI collection date are displayed if more than one sampling event occurred.

Table 8.13 Summary of DRI Monitoring Results - 2000 (pCi/L)

Locations	Gross Alpha	Gross Alpha Error	Gross Alpha MDC	Gross Beta	Gross Beta Error	Gross Beta MDC	Gamma Spectrum	Gamma Spectrum Error	Gamma Spectrum MDC	^{238}Pu	^{238}Pu Error	^{238}Pu MDC	$^{239+240}$Pu	$^{239+240}$Pu Error	$^{239+240}$Pu MDC
pm-3#1	8.3	3.8	5	15.5	4	5.2	-2	11	21						
pm-3#2	1.2	1.8	3	17.3	3.7	4.5	5	6.2	12						
pm-3#2	1.9	2	3.2	13.8	3.5	4.7	-6.8	7.3	15						
Coffers	9.1	2.2	1.7	4.8	1.5	2.1	-3.3	8.4	15	0.005	0.077	0.22	0.025	0.05	0.067
ER-OV-01	24.2	4.7	2.4	20.8	3.6	3.7	-16	11	19	-0.03	0.036	0.27	-0.01	0.02	0.21
ER-OV-02 (bailed)	37.1	7.2	4	36.2	5.7	5.3	^{137}Cs 2.4, ^{210}Pb 200	7.0, 200	13, 120	-0.028	0.091	0.22	0.014	0.07	0.15
ER-OV-02 (pumped)	20	2.5	0.9	10.1	1.5	1.6	4.4	8.2	16	-0.131	0.076	0.38	0.12	0.2	0.31
ER-OV-03c	14.6	3.2	1.8	11.9	2.7	3.3	5.5	9.4	20	0.12	0.23	0.39	-0.011	0.023	0.23
ER-OV-03c2	15.2	3.8	3.2	11.3	2.7	3.5	14.7	9.6	16	0.042	0.088	0.16	-0.02	0.21	0.16
ER-OV-6a	11.5	3.7	3.7	14	2.9	3.4	-2.2	9.7	19	0.06	0.2	0.37	-0.064	0.051	0.3

Pahute Mesa (No Date Provided)

9.0 QUALITY ASSURANCE

It is the policy of the U. S. Department of Energy, National Nuclear Security Administration Nevada Operations Office (NNSA/NV) that all data produced for its environmental surveillance and effluent monitoring programs be of known quality. Therefore, a quality assurance (QA) program is used for collection and analysis of samples for radiological parameters to ensure that data produced by the Bechtel Nevada (BN) in-house Analytical Services Laboratory (ASL) and Subcontracted Radiochemistry Laboratory meets customer-and regulatory-defined requirements. Data quality is assured through process-based QA, procedure-specific QA, measurement quality objectives (MQOs), and performance evaluation programs (PEPs). The QA program for radiological data consists of participation in the Quality Assessment Program (QAP) administered by the NNSA/NV Environmental Measurements Laboratory (EML), the InterLaB RadCheM™ Proficiency Testing Program directed by Environmental Resource Associates (ERA), the Radiochemistry Intercomparison Program provided by the National Institute of Standards and Technology (NIST), and the Mixed Analyte Performance Evaluation Program (MAPEP) conducted by the Idaho National Engineering and Environmental Laboratory (INEEL). Thermoluminescent dosimeter (TLD) radiation measurement QA for the program is assessed by the BN Dosimetry Group's participation in the NNSA/NV's Laboratory Accreditation Program and intercomparisons provided by the Battelle Pacific Northwest National Laboratory (PNNL) during the course of the year.

9.1 POLICY

Environmental surveillance, conducted onsite by BN, is governed by the NNSA/NV QA policy as set forth in DOE Order 414.1A (DOE 1999). The Order outlines ten specific elements that must be considered for compliance with the QA policy. These elements are:

1. Program
2. Personnel Training and Qualification
3. Quality Improvement
4. Documents and Records
5. Work Processes
6. Design
7. Procurement
8. Inspection and Acceptance Testing
9. Management Assessment
10. Independent Assessment

9.2 OVERVIEW OF THE LABORATORY QA PROGRAM

The BN in-house Analytical Services Laboratory (ASL) and the Subcontracted Radiochemistry Laboratory implements the requirements of the DOE Order O 414.1A through integrated quality procedures. The quality of data and results is ensured through both process-based and procedure-specific QA. BN is assured of quality data from the Subcontractor through both a review of the Subcontractor's QA Plan by BN as well as the Subcontractor's successful participation in the NNSA's Environmental Consolidated Audit Program (EMCAP).

Procedure-specific QA begins with the development and implementation of Organizational Procedures (OPs), which contain the analytical procedures and required quality control samples for a given analysis. Personnel performing a given analysis are trained and qualified for that analysis, including the successful analysis of a quality control sample. Analysis-specific operational checks and calibration standards traceable to either the NIST or the U. S. Environmental Protection Agency (EPA) are required. Quality control samples, e.g., spikes, blanks, and replicates, are included for each analytical procedure. Compliance with analytical procedures is measured through procedure-specific assessments or surveillances.

An essential component of process-based QA is data review and verification to assess data usability. Data review requires a systematic, independent review against pre-established criteria to verify that the data are valid for their intended use. Initial data processing is performed by the analyst or health physicist generating the data. An independent review is then performed by another analyst or health physicist to ensure that data processing has been correctly performed and that the reported analytical results correspond to the data acquired and processed. Supervisory review of data is required prior to release of the data to sample management personnel for data verification. Data verification ensures that the reported results correctly represent the sampling and/or analyses performed and includes assessment of quality control sample results. Data processing by sample management personnel ensures that analytical results meet project requirements. Data checks are made by Environmental Technical Services of BN for internal consistency, proper identification, transmittal errors, calculation errors, and transcription errors.

Process-based QA programs also include periodic operational checks of analytical parameters such as reagent water quality and storage temperatures. Periodic calibration is required for all measuring equipment such as analytical balances, analytical weights, and thermometers. The overall effectiveness of the QA program is determined through systematic assessments of analytical activities. Systematic problems are documented and corrective actions tracked through System Deficiency Reports.

Similar procedures and methodologies are used by the Subcontracted Radiochemistry Laboratory to ensure the quality of environmental radiological data they produce.

9.3 MEASUREMENT QUALITY OBJECTIVES (MQOs)

MQOs are commonly described in terms of representativeness, comparability, precision, accuracy, blank analysis, and interlaboratory comparison studies. Definite numerical goals may be set and quantitative assessments performed for these components of the data.

REPRESENTATIVENESS

Representativeness is the degree to which a sample is truly representative of the sampled medium; i.e., the degree to which measured analytical concentrations represent the concentrations in the medium being sampled (Stanley and Verner 1985).

Representativeness also refers to whether the locations and frequency of sampling are such that calculational models will lead to a correct estimate of potential EDE to a member of the public when measured radioactivity concentrations are put into the model. An environmental monitoring plan for the, "Nevada Test Site Routine Radiological Environmental Monitoring Plan" (DOE 1998a) has been established to achieve representativeness for environmental data. Factors which were considered in designing this monitoring plan include locations of known and potential sources, historical and operational knowledge of isotopes and pathways of concern, hydrological, and topographical data, and locations of human populations.

COMPARABILITY

Comparability refers to the degree of confidence and consistency in the laboratorie's analytical results, or defined as "the confidence with which one data set can be compared to another" (Stanley and Verner 1985). To achieve comparability in measurement data, sample collection and handling, laboratory analyses, and data analysis and validation are performed in accordance with established OPs. Standard reporting units and a consistent number of significant digits are used. Instruments are calibrated using NIST-traceable sources. Extensive QA measures are used for all analytical processes.

PRECISION

Precision refers to "the degree of mutual agreement characteristic of independent measurements as the result of repeated application of the process under specified conditions" (Taylor 1987). Practically, precision is determined by comparing the results obtained from performing the same analysis on split samples, or on duplicate samples taken at the same time from the same location, maintaining sampling and analytical conditions as nearly identical as possible. Precision for samples is determined by comparing results for duplicate samples of particulates in air, tritiated water vapor, TLDs, and of some types of water samples. Control limits for duplicates have been established at $\pm$ detection level for results less than 5 times detection level. If the result is greater than 5 times detection level, then results must be $\pm$ 20 percent Relative Percent Difference (RPD).

ACCURACY

Accuracy refers to how well we can measure the true value of a given quantity and can be defined as "the degree of agreement of a measured value with the true or expected value of the quantity of concern" (Taylor 1987). For practical purposes, assessments of accuracy for the ASL and Subcontract Radiochemistry Laboratory are done by performing measurements on a Laboratory Control Sample (LCS) which is sometimes called a Blank Spike Sample (BSS). An LCS is a control sample of known composition which is analyzed using the same sample preparation, reagents, and analytical methods as employed for the project samples.

The accuracy of these measurements, which is assumed to extend to other similar measurements performed by the laboratory, may be defined as the ratio of the measured value divided by the true value, expressed as a percent. The control limits (in percent) for accuracy that is monitored by using LCS results, are 80 to 120 percent except for gross alpha and beta which are 50 to 120 percent.

BLANK ANALYSIS

A blank analysis is an artificial sample designed to monitor the introduction of artifacts into the measurement process. There are several types of blanks which monitor a variety of processes:

- **A laboratory blank** is taken through sample preparation and analysis only. It is a test for contamination in sample preparation and analyses.

- **A holding blank** is stored and analyzed with samples at the laboratory. It is a test for contamination in sample storage as well as sample preparation and analysis.

- **A trip blank** is shipped to and from the field with the sample containers. It is not opened in the field and, therefore, provides a test for contamination from sample preservation, site conditions, and transport as well as sample storage, preparation, and analysis.

- **A field blank** is opened in the field and tests for contamination from the atmosphere as well as from sample preservation, site conditions, transport, sample storage, preparation, and analysis.

For the BN Environmental Monitoring Program laboratory blanks are monitored, with a control limit of less than the detection level being used.

INTERLABORATORY COMPARISON STUDIES

The BN in-house Analytical Services Laboratory (ASL) and Subcontracted Radiochemistry Laboratory analyze special QA samples that are prepared, using stringent quality control, by laboratories which specialize in preparing such samples. The values of the activities of these samples are not known by the staff of the ASL or the Subcontracted Laboratory until several months after the measurements are made and the results sent back to the QA laboratory. These sample values are unknown to the analysts and serve to measure the capability of a laboratory for analyzing an analyte in a specific matrix.

The interlaboratory comparison studies that the ASL and Subcontracted Radiochemistry Laboratory participate in are the Quality Assessment Program (QAP) administered by the NNSA Environmental Measurements Laboratory (EML), the InterLaB RadCheM™ Proficiency Testing Program directed by Environmental Resource Associates (ERA), the Radiochemistry Intercomparison Program provided by the National Institute of Standards and Technology (NIST), and the Mixed Analyte Performance Evaluation Program (MAPEP) conducted by the Idaho National Engineering and Environmental Laboratory (INEEL).

The capability of the BN Dosimetry Group's TLD program is tested during the course of the year by their participation in the Battelle Pacific Northwest National Laboratory (PNNL) performance evaluation study program. They are also tested every two or three years by the NNSA's Laboratory Accreditation Program. This involves a three-part, single blind performance testing program followed by an independent onsite assessment of the overall program.

9.4 RESULTS FOR DUPLICATES, LABORATORY CONTROL SAMPLES, BLANK ANALYSIS, AND INTERLABORATORY COMPARISON STUDIES

A brief discussion of the year 2000 results for duplicates, laboratory control samples, blank analysis, and interlaboratory comparison studies are provided within this section. Summary tables are also included.

DUPLICATES (PRECISION)

The duplicate sample results obtained for 2000 are summarized in Table 9.1. All analysis/matrix categories had 75 percent or better of their field duplicates fall within the established control limits except for ^{226}Ra in water and $^{239+240}$Pu in water and air. With only three duplicates reported during the year for ^{226}Ra there are too few data points to come to any logical conclusions. However with 13 duplicate results being reported for $^{239+240}$Pu in both air and water, a legitimate problem does appear to exist with this method routinely meeting the given control limits. Table 9.1 shows that only 7 of 13 duplicate results (54 percent) reported for the air matrix and 9 of 13 duplicate results (69 percent) reported for the water matrix are in control. This is perhaps a result of the uncertainties associated with the sample dissolution during chemical preparation and the counting efficiency of the alpha spectroscopy counting technique. The variance of air volumes and air pressures experienced during sample collection as well as the transfers of multiple air filters for screening and compositing could also be contributing factors to the poor duplicate precision observed for the air matrix. Wider acceptance windows should be investigated for use with the $^{239+240}$Pu analysis for both the air and water matrices in the future.

LABORATORY CONTROL SAMPLES (ACCURACY)

The laboratory control sample (LCS) results obtained for 2000 are summarized in Table 9.2. The LCS results were satisfactory with no more than one result being out of control for any given analysis/matrix category for the year.

BLANK ANALYSIS

The laboratory blank sample results obtained for 2000 are summarized in Table 9.3. The laboratory blank results were satisfactory with no more than one result being out of control for any given analysis/matrix category for the year.

INTERLABORATORY COMPARISON STUDIES

The interlaboratory comparison sample results obtained for 2000 are summarized in Tables 9.4 through 9.6.

Table 9.4 shows the summary of interlaboratory comparison sample results for the BN in-house Analytical Services Laboratory (ASL). The ASL participated in the InterLaB RadCheM™ Proficiency Testing Program directed by Environmental Resource Associates (ERA), the Quality Assessment Program (QAP) administered by the NNSA Environmental Measurements Laboratory (EML), the Radiochemistry Intercomparison Program provided by the National Institute of Standards and Technology (NIST), and the Mixed Analyte Performance Evaluation Program (MAPEP) conducted by the Idaho National Engineering and Environmental Laboratory (INEEL). The ASL performed very well during the year by passing 56 out of 58 parameters analyzed. The only outliers were two ^{65}Zn results analyzed by gamma spectroscopy for the ERA program. Both results were out of control with high bias.

Table 9.5 shows the summary of interlaboratory comparison sample results for the Subcontracted Radiochemistry Laboratory. The Subcontractor participated in the InterLaB RadCheM™ Proficiency Testing Program directed by ERA, the QAP administered by EML, and the MAPEP conducted by INEEL. The Subcontractor performed very well during the year by passing 45 out of 48 parameters analyzed. Two of the outliers were ^{226}Ra results analyzed by radon emanation technique for the ERA program. One of these results was reported with high bias, while the other was reported with low bias. The laboratory was successful in passing two other ERA performance evaluation rounds of ^{226}Ra during the year. The third outlier was ^{134}Cs, which was analyzed by gamma spectroscopy for the ERA program and was reported with low bias.

Table 9.6 shows the summary of interlaboratory comparison sample results for the BN in-house Dosimetry Group. They participated in the Battelle Pacific Northwest National Laboratory (PNNL) performance evaluation study program during the course of the year. The Dosimetry Group performed very well during the year by passing 17 out of 18 TLDs analyzed. The only outlier was a S60/Cf-252 UN. Mixture (1:3) within the test range of 0.03 to 5 rem.

9.5 ESTIMATES OF DATA QUALITY

The measurement quality as discussed in Section 9.3 indicate that representativeness, comparability and quality control of the data reported are acceptable. Further, data completeness for this data set met or exceeded completeness goals so these data are acceptable for their intended use.

Table 9.1 Summary of Field Duplicate Samples - 2000

Analysis	Number of Duplicate Matrix	Number of Results Reported	Number Within Control Limits[(a)]
Gross Alpha	Air	72	59
Gross Beta	Air	72	66
$^{239+240}Pu$	Air	13	7
Gamma	Air	29	25
Tritium	Air	36	32
Gross Alpha	Water	5	5
Gross Beta	Water	14	12
$^{239+240}Pu$	Water	13	9
Gamma	Water	33	26
Tritium	Water	44	41
^{90}Sr	Water	6	6
^{226}Ra	Water	3	1
^{228}Ra	Water	3	3
TLDs	Ambient Radiation	380	363

(a) Control limits are as follows: If the result is less than 5 times detection level, then duplicate results must be $\pm$ detection level. If the result is greater than 5 times detection level, then results must be $\pm$ 20 percent (Relative Percent Difference). The $\pm$ 20 percent Relative Percent Difference is used as the control limit for all TLD duplicates.

Table 9.2 Summary of Laboratory Control Samples (LCS) - 2000

Analysis	Matrix	Number of LCS Results Reported	Number Within Control Limits[a]
Gross Alpha	Air	18	16
Gross Beta	Air	18	18
$^{239+240}Pu$	Air	8	8
Gamma	Air	30	30
Tritium	Air	12	11
Gross Alpha	Water	8	8
Gross Beta	Water	11	11
$^{239+240}Pu$	Water	6	6
Gamma	Water	34	34
Tritium	Water	23	22
^{90}Sr	Water	5	4
^{226}Ra	Water	3	2
^{228}Ra	Water	3	2

(a) Control limits are as follows: 80 to 120 percent for all analyses and matrices except for gross alpha and beta which are 50 to 120 percent.

Table 9.3 Summary of Laboratory Blank Samples - 2000

Analysis	**Matrix**	**Number of Blank Results Reported**	**Number Within Control Limits[(a)]**
Gross Alpha	Air	36	36
Gross Beta	Air	36	35
$^{239+240}Pu$	Air	8	8
Gamma	Air	21	21
Tritium	Air	10	10
Gross Alpha	Water	8	8
Gross Beta	Water	11	11
$^{239+240}Pu$	Water	6	6
Gamma	Water	31	31
Tritium	Water	22	22
^{90}Sr	Water	5	5
^{226}Ra	Water	3	3
^{228}Ra	Water	3	3

(a) Control limit is less than detection level.

Table 9.4 Summary of Interlaboratory Comparison Samples for the BN in-house Analytical Services Laboratory - 2000

Analysis	**Matrix**	**Number of Results Reported**	**Number Within Control Limits**[(a)]
ERA Results			
Gross Alpha	Water	4	4
Gross Beta	Water	4	4
Gamma	Water	16	14
Tritium	Water	1	1
^{90}Sr	Water	3	3
^{226}Ra	Water	2	2
^{228}Ra	Water	2	2
EML Results			
Gross Alpha	Air	1	1
Gross Beta	Air	1	1
$^{239+240}$Pu	Air	1	1
Gamma	Air	5	5
Gross Alpha	Water	1	1
Gross Beta	Water	1	1
$^{239+240}$Pu	Water	1	1
Gamma	Water	3	3
Tritium	Water	1	1
^{90}Sr	Water	1	1
NIST Results			
$^{239+240}$Pu	Air	1	1
^{90}Sr	Air	1	1
MAPEP Results			
Gamma	Water	6	6
$^{239+240}$Pu	Water	1	1
^{90}Sr	Water	1	1

(a) Control limits are determined by the individual interlaboratory comparison study.

Table 9.5 Summary of Interlaboratory Comparison Samples for the Subcontract Radiochemistry Laboratory - 2000

Analysis	Matrix	Number of Results Reported	Number Within Control Limits[a]
		ERA Results	
Gross Alpha	Water	2	2
Gross Beta	Water	2	2
Gamma	Water	8	7
Tritium	Water	1	1
^{90}Sr	Water	3	3
^{226}Ra	Water	4	2
^{228}Ra	Water	3	3
		EML Results	
Gross Alpha	Air	1	1
Gross Beta	Air	1	1
$^{239+240}Pu$	Air	1	1
Gamma	Air	4	4
Gross Alpha	Water	1	1
Gross Beta	Water	1	1
$^{239+240}Pu$	Water	1	1
Gamma	Water	4	4
Tritium	Water	1	1
^{90}Sr	Water	1	1
		MAPEP Results	
Gamma	Water	7	7
$^{239+240}Pu$	Water	1	1
^{90}Sr	Water	1	1

(a) Control limits are determined by the individual interlaboratory comparison study.

Table 9.6 Summary of Interlaboratory Comparison Thermoluminescent Dosimeter (TLD) Samples for the BN in-house Dosimetry Group - 2000

Analysis	Matrix	Number of Results Reported	Number Within Control Limits[a]
TLDs	Ambient Radiation	18	17

(a) Control limits are determined by the Battelle Pacific Northwest National Laboratory (PPNL) performance evaluation study program.

Shoshone Mountain Looking South of Mid Valley (No Date Provided)

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